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UNIVERSITY OF MICHIGAN

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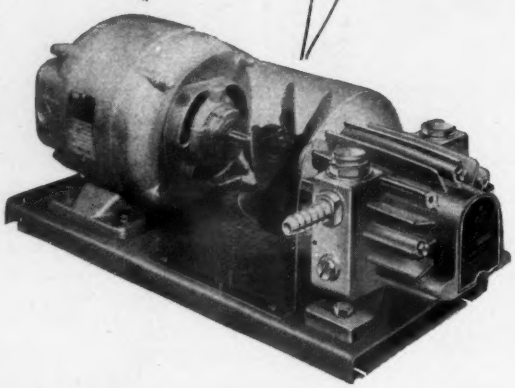

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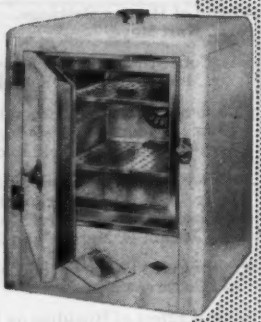

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SCIENCE AND TECHNOLOGY IN THE UNITED STATES

THE appointment of Dr. J. R. Killian as special assistant for science and technology to President Eisenhower and the expansion of the activities of the National Science Foundation which followed swiftly on President Eisenhower's message to Congress of January 27, 1958, have been welcomed as facilitating Anglo-American co-operation and strengthening the organization of the Western world both in science and in defence. The essential ideas for these developments are to be found in reports issued earlier, notably in Dr. Vannevar Bush's report, "Science—the Endless Frontier", and the Steelman report, "Science and Public Policy" in the United States, and in the Barlow report on scientific staff in Great Britain. The United States is now, indeed, giving effect to ideas which in Great Britain have found expression in the establishment of the Advisory Council on Scientific Policy and the Defence Research Policy Committee, for example.

The address on "Science and Public Policy" which Dr. Killian delivered on December 25 to the American Association for the Advancement of Science shows how vigorously the Federal Government is implementing the new policy and how much has already been done to strengthen the position of both science and technology in the United States. This first report of Dr. Killian on the work of his office and of the President's Science Advisory Committee* is of great interest to the scientist and technologist in Britain, not only as summarizing what has been done but also from the point of view of eliminating weaknesses in our organization which have become apparent during the past year or so. Reference has indeed already been made in these columns to the report of the Science Advisory Committee's Panel on Scientific Information. This address, and the report of the Committee's Panel on Research Policy, to which Dr. Killian refers in detail, provide ample evidence to justify Dr. Killian's claim that the President's proposals have already been translated into action.

The expansion of the National Science Foundation, the available funds of which have been increased from 50 million dollars in 1958 to 136 million in 1959, may be appropriately left for consideration with the Foundation's latest annual report, merely noting Dr. Killian's view that it is now one of the Government's major means for advancing science and supporting basic research. Next, Dr. Killian notes the creation, under the Department of Defence Reorganization Act, of a new post of Director of Research and Engineering in Defence, and of the Advanced Research Projects Agency, to sponsor long-range research for defence and to undertake projects of common interest to the military Services. The former appointment indicates the importance now attached in the United States to the formulation at a high level of research and development defence policy and to the supervision of an overall programme. Besides this, the National Aeronautics and Space Administration has been created to provide a civilian-directed and civilian-oriented programme of space science and exploration, including research support for military aeronautics and space programmes, with a National Aeronautics and Space Council, advisory to and presided over by the President.

This new pattern of organization of scientific and technological research in the United States and of advisory service to the Government is quite distinct from the structure existing in Great Britain, but there are some similarities. These similarities are perhaps more marked in the work of the Science Advisory Committee and in the recently established Federal Council for Science and Technology, while on the educational side, under the National Defence Education Act, measures have been taken to strengthen science education that are probably more vigorous than those yet adopted in Britain. Likewise, the recent appointment by the State Department of seven scientific attachés suggests that the United States Government is giving more weight to such appointments than the British Government has yet done in spite of the recommendations of the Advisory Council on Scientific Policy.

Dr. Killian emphasizes that neither he, nor the Science Advisory Committee, has any executive responsibilities. Like the Advisory Council on Scientific Policy in Britain, their functions are purely advisory and they do not even share such responsibilities for the decision of policy as fall on the Lord President of the Council. They are charged with providing the best scientific advice and with making recommendations for the advancement of science and technology in the United States, especially by the Federal Government and in matters relating to security and welfare. A principal function is to provide a communications centre for science in the Federal Government, and thus to facilitate intercommunication among various scientific activities within the Government and between the civilian scientific community and the Government.

As in Britain, this is achieved to a considerable extent by the common membership of committees, as well as by the rotation of much of the membership, while the group of panels organized under the Science Advisory Committee enlist the advice and services of a very wide range of experience and knowledge, numbering at present about seventy-five scientists and engineers. Moreover, the Special Assistant for Science and Technology is invited to attend meetings of the National Security Council and the Cabinet, and, when appropriate or requested, to present the views and findings of the Science Advisory Committee. Objective scientific and technological advice can thus be presented effectively at

*A Statement by the President, and Strengthening American Science: a Report of the President's Science Advisory Committee. Pp. iii+36. (Washington, D.C.: Government Printing Office, 1958.) 20 cents.

the highest level of government, and it would appear probable that the United States has now a more effective means than Great Britain for ensuring that science and technology play a direct and creative part in formulating public policy. Moreover, particular attention is being given to the problem of placing at the disposal of the Government the creative powers and talent of the younger scientists and technologists, without handicapping either their professional development or their creative work in science and technology.

The principal recommendation in the report, "Strengthening American Science", of the Science Advisory Committee's panel on research policy is the establishment of a Federal Council for Science and Technology to advise the Cabinet on those aspects of the Government's programme which require interdepartmental and Government-wide co-ordination and policy, and which affect science as a whole. The President has already authorized an executive order establishing this Council, and, as recommended by the Committee, membership of the Council will include representatives of the departments and agencies which have substantial research activities, and these representatives will be drawn from the policy-making level. The Committee suggested, for example, that the Council should include the Director of the National Science Foundation, the Commissioner of the Atomic Energy Commission, the Administrator of National Aeronautics and Space Administration and the Director of Defence Research and Engineering; but the Council will be able to call for advice from the Science Advisory Committee, the members of which are largely drawn from outside Government service.

In constitution and membership, the new Council thus appears to be drawn from a higher level than the Council for Scientific and Industrial Research in Britain, and for that reason may well prove a more effective instrument for concerting and co-ordinating Government policy in scientific and technological matters and in all national concerns where such factors are important. The Council is specifically to consider problems and developments in science and technology which affect more than one department or agency, and to recommend policies and other measures to promote the more effective planning and administration of Federal scientific and technical programmes. To that end the Council is to prepare a projection of the programme costs required to meet Federal needs, including both capital and man-power, and to consider the level and type of research financed by the private sector of the economy. It is also to promote effective utilization of Government resources and full co-operation among Government agencies, as well as consider and recommend measures for implementing policy decisions affecting the administration and conduct of Federal programmes in science and technology.

As thus conceived, the new Council, while still advisory, like the Advisory Council for Scientific Policy in Britain, appears to have functions going beyond those of the latter, and much further than those of the Council for Scientific and Industrial Research; and, as already noted, the higher level at which its membership is linked with Government may make it more influential and effective. Much will depend, none the less, on how clearly its advice and recommendations are understood by the Government; but scientists and technologists could scarcely expect their advice to be presented at a higher level. Moreover, the structure proposed appears to be reasonably flexible and to avoid the excessive centralization of authority that can be so inimical to the obtaining and presentation of the best scientific and technical advice.

It remains to be seen how far in practice these new arrangements will solve for the American scientist and technologist the difficult problems of power and responsibility, but they seem to afford reasonable prospect of the scientist and technologist exerting effective influence on public policy. It is not expected that the new Council will solve all the problems in managing research conducted by the Government, but it should assist Government departments in the United States to strengthen their own laboratories and to ensure a fuller and more economic use of their scientific resources. Moreover, the Panel on Research Policy is particularly concerned with the financing and planning of such highly expensive research equipment as particle accelerators in nuclear physics, and the research institutes which are needed or have been proposed in various fields. It recognizes the importance of considering carefully the relation of such institutes to the universities, and the danger of weakening the universities if unsound planning draws away from them too many research workers.

In this connexion, too, the Panel stresses the importance of greater emphasis on basic research. At present about 6 per cent of the U.S. Government's total budget for research and development of more than 5,000 million dollars in 1959 is earmarked for basic research, and the Panel is convinced that more vigorous support of basic research during the past decade would have paid rich dividends in reducing the cost of development. Stress is laid on nurturing new scientific fields and strengthening those, like meteorology, which are assuming new importance. Geology, geophysics, oceanography, radio astronomy, materials research and combustion are also mentioned as needing increased support and effort.

With its limited resources, Great Britain needs to select even more carefully than the United States the objectives of her research effort; this is a task to which the Council for Scientific and Industrial Research should be giving attention before reaching its decisions about the work of its own research stations. Had there been evidence of such a wider view, particular decisions like those taken in regard to fuel research and the discontinuance of *Fuel Abstracts* might have been less open to challenge. In directing attention last year to the need for the creation of new institutions for fundamental research in particular fields or sub-fields of science, the National Science Foundation stressed the importance of obtaining ample evidence where it is thought that

existing facilities are inadequate or inappropriate, and it is no less important in closing down work in a particular field to be sure that appropriate facilities exist elsewhere.

The Panel on Research Policy in this report discusses also the problem of sponsored research in non-Government institutions and recommends more consideration of programme grants as a means of reducing the potential growth of Government administration and providing greater freedom for the scientific community to direct the work. It also recognizes the importance of the independent research foundation and private industry, and the need to avoid discouraging such support of research. The climate as well as the means have to be created whereby ideas which are challenging and sound but unconventional and difficult can be hospitably considered and encouraged.

Dr. Killian refers next to the activities of a Panel on Science and Technology in Foreign Affairs which has been concerned notably with aid to underdeveloped countries, the re-establishment of the posts of scientific attachés, and the creation of the necessary atmosphere for effective interchange of ideas and international scientific co-operation. Again, he describes at some length the study, by the Panel on Science and Engineering Education, of the objectives and needs of that part of the educational system which is responsible for supplying adequate numbers of first-rate scientists and engineers and achieving a high degree of scientific literacy. This Panel was convinced that some of the major challenges facing the United States to-day are on the intellectual front and that, in the long run, a greater desire to learn and increased respect for intellectual excellence may be essential to national survival—a view which Dr. Warren Weaver has elaborated in an article in *The Scientific American*.

This may be equally true of Great Britain, and it is certainly true that, in considering our educational problems at any level, we, too, should be considering how such objectives can best be achieved. From this point of view alone, it is of interest to note three specific conclusions reached by this Panel. First, because in the immediate future the rising number of students will outstrip the supply of teachers, it is necessary to find new ways of increasing the effectiveness of existing teachers. Secondly, more attention should be given to the quality and content of courses and curricula in science. Thirdly, in the judgment of the Panel, *in relation to national responsibilities* and opportunities in science, the United States has too few first-rate institutions of higher education in science and engineering, so that there is real danger of overloading the few departments of the highest quality.

The Minister of Education, Mr. Geoffrey Lloyd, remarked in the House of Commons on March 12 that his main impression on his recent visit to the United States was that the American and British educational systems are growing closer together, and that each in its own way is seeking to combine equal educational opportunity with high academic standards, particularly for specially gifted children. The three specific conclusions of the Panel relate to American conditions but are essentially valid elsewhere, particularly if it is intended to pay greater attention to specially gifted children. Moreover, as Dr. Killian emphasizes, the quality of science and of scientific education depends on the quality of the intellectual life in the society in which they are nurtured, and his plea for adequate attention to the cultivation of talent, quality and intellectual ability is one to be heeded equally in Britain.

In reaffirming his belief in the capacity of man to improve both himself and his society, Dr. Killian rejected the note of pessimism to be found in Britain as well as in the United States. He insisted that science does not contribute simply to the comfort and convenience of life: it contributes also to its quality, to the individuality from which creative work arises, to its dignity as well as to its productivity. Science, he claimed, is one of the great disciplines vital to society and worthy of first-class minds, and the growing linkage of science and technology with government demands of science a new order of poise and statesmanship, and of the scientists who serve as advisers a deep understanding of the role and limitation of the adviser. It is only when this conception of science as one of man's most powerful means for searching out truth and augmenting his dignity is fully and widely recognized that science can prosper in any country and attract its proper complement of creative and gifted minds.

It would be foolish to suggest that the new structure for bringing science and technology to play their fitting part in public policy in the United States should be slavishly imitated in Britain. The importance to Britain of Dr. Killian's review and of the report on strengthening science in the United States lies rather in indicating factors which should receive closer attention, in suggesting points of view from which our own organization may well need re-appraisal, dangers to be avoided and problems on which new and creative thinking is required. The emphasis on education is to be noted above all, for on that finally depends both the effectiveness with which science and technical advice is presented and the understanding with which it is received. Whatever criticisms may well be made as to the shortcomings of the British organization for bringing science to bear on public policy, the address which the Prime Minister gave to the Parliamentary and Scientific Committee at its annual luncheon on February 18 shows how largely this is already recognized.

Mr. Macmillan referred to the opportunities he had of listening to scientific advice, particularly in view of his departmental responsibility for the Atomic Energy Authority, and to the Government's duty to increase the scientific potential, including the provision of sufficient trained man-power through the educational system and the development of scientific and technological teaching in the schools, technical colleges and universities, as well as the provision of adequate and varied facilities for

research. With his reference to the importance of international co-operation in this field, including the decision at Montreal to establish an Overseas Research Council, Mr. Macmillan's address showed that attention is already being given to the several aspects of Government support for science and technology discussed by Dr. Killian, and if the scale of that support can sometimes be challenged, the Government is at any rate aware of a responsibility. Mr. Macmillan pointed out that a Minister has, in fact, much in common with the scientist: like him, he must always be ready to study and use all known facts bearing on a problem; to search dispassionately for truth and right answers; and to be ready to recognize them when the facts force them on our understanding, whatever the cost to our previous beliefs or prejudices. No scientist could ask or expect more than that a Minister should show the courage and vision to act on such principles, or that a Government should be, as Mr. Macmillan affirmed, alert to such scientific advice, not only about what it is doing now, but also about what it might be doing five, ten or twenty years hence. Mr. Macmillan's address to the Parliamentary and Scientific Committee should encourage the scientist and technologist to examine and explore the possibilities of improving our research organization, our advisory services and our educational system; Dr. Killian's review of the work of the Science Advisory Committee may suggest with greater confidence that the task will be well worth while.

GREAT THINKING

The Physicist's Conception of Nature

By Prof. Werner Heisenberg. Pp. 192. (London: Hutchinson and Co. (Publishers), Ltd., 1958.) 16*s*. net.

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Mind and Matter

By Prof. Erwin Schrödinger. (The Tarner Lectures delivered at Trinity College, Cambridge, in October 1956.) Pp. vii+104. (Cambridge: At the University Press, 1958.) 13*s*. 6*d*. net.

A LARGE part of Prof. Heisenberg's book is entitled "Historical Sources", and consists of long quotations of great writers on physical science from Kepler to Louis de Broglie. These are selected to show the "changes in the attitude of science" that have occurred during the development of 'modern' science. Needless to say, a selection from such great thinkers made by another great thinker is in itself of profound interest. But it immediately occurs to one that we have before us some of the writings of three of the greatest contributors to the latest phase of the development; one wonders how another Heisenberg of, say, 300 years hence might quote from them in making a corresponding selection for his own time and how true an impression of this phase would be given thereby. This in turn makes one wonder what is the real significance of a selection such as Heisenberg himself has made.

The first point that seems relevant to these considerations is somewhat prosaic. Some of the contents of these books are invited addresses for various public occasions. The very care that the authors have taken to suit their particular audiences hinders them from being wholly 'professional' accounts of their subjects. Far more, one questions whether, for example, Heisenberg's first quotation from the dedication of the "Mysterium Cosmographicum" to "their Illustrious, High-born, Noble and Righteous Lords . . ." should be treated critically as the record of Kepler's scientific attitude. Again, the most fascinating parts of Prof. Schrödinger's books are his personal reflexions upon the perennial problems of the place of science in human thought; they largely transcend the particular phase of physical science to which he has contributed. Similarly, one asks if, for example, Heisenberg's quotations from W. Ostwald, who was a less inspired thinker and writer than Schrödinger, are more than his personal reflexions and if they serve to give a just indication of the contemporary trend of physical thought.

Of the dozen writers quoted by Heisenberg, probably only Galileo, Newton and de Broglie have themselves made advances in the most fundamental development of physics more important than, or as important as, those made by the three authors of the present books. Moreover, it happens that these authors have written here and elsewhere with very deep penetration about the significance of the developments to which they have contributed so much.

In passing, we may learn something from the fact that Heisenberg quotes nothing from Hamilton, Faraday, Maxwell or Rutherford, whose work contributed vastly more to the development of physics than that of the majority of writers on his list. It is that physics itself is just what it is gradually discovered to be, and physicists who are prepared to take it, literally, as they find it are able to make great progress. If it be contrary to their cast of mind to trouble much about questions of significance, that probably makes no difference to their strictly scientific work. This is almost inevitably the case, since advances come by not over-rating the significance of previous work and they have to come before their own significance can be discussed. The attitude of such physicists towards their work is akin to that of a pure mathematician in his field.

Nevertheless, for most of us it is a truism that the interest of scientific advances is in what we call their significance; and what Bohr, Heisenberg and Schrödinger are doing is to stand back from their own work in order to survey its setting in wider fields of thought and its possible influence upon such thought. Bohr's book is a collection of essays and addresses prepared over the years 1932–57, and they have all had extreme care bestowed upon them. The author says himself, "The theme . . . is the epistemological lesson which the modern development of atomic physics has given us and its relevance for analysis and synthesis in many fields of human knowledge". Heisenberg's book consists, in the first part, of a sketch of the attitude to Nature in modern physics, together with general considerations regarding intellectual problems confronting man in the situation produced by the development of his own

science and technology. The second part consists of the "sources" already mentioned, which are claimed to show that modern science started with an awareness of the limitations of its scope, passed through a phase in which it forgot its own limitations, and is now appreciating these limitations with new insight. The first of Schrödinger's books is a re-issue, with one addition, of the essays previously published in "Science and the Human Temperament" (1935). His second book consists of the Tarner Lectures for 1956. It is the most far-ranging of all these books and, in one way or another, bears upon the whole range of human thought. To the reviewer it breathes a freer air than do the others. This is perhaps because Schrödinger seems less prone to regard recent developments as supremely decisive in the long roll of man's thinking and so it comes more naturally to him to look beyond them. Whereas Heisenberg says, "When we speak of the picture of nature in the exact science of our age, we do not mean a picture of nature so much as a *picture of our relationships with nature*", Schrödinger says, "*The world is given to me only* once, not one existing and one perceived. Subject and object are only one. The barrier between them cannot be said to have broken down as a result of recent experience in the physical sciences, for this barrier does not exist".

However, when these distinguished authors stand back to survey the whole realm of thought, it cannot be expected of the writer of a short review to stand even farther back to survey the survey. All he can do is to urge others to enjoy the extraordinary richness of thought contained in each of these brief volumes.

W. H. McCrea

ADVANCES IN MICROBIOLOGY

Annual Review of Microbiology

Vol. 12. Edited by Charles E. Clifton in association with Sidney Raffel and Mortimer P. Starr. Pp. viii + 579. (Palo Alto, Calif.: Annual Reviews, Inc., 1958.) 7 dollars.

IN these days when the expanding volume of literature is the despair of every scientist who hopes to keep abreast of advance in anything more than a narrow field, the annual review volumes have become indispensable. They serve two purposes: to provide a rapid guide to recent literature and, more rarely, to present an appreciation and synthesis of recently acquired knowledge. The latter type of review article is only possible when knowledge in a particular branch has reached a degree of attainment and significance that enables something more than appraisal of detail to be attempted. Three of the major articles in the present "Annual Review of Microbiology" are in this latter class and each makes a valuable contribution in its own right: "Metabolism of Carbohydrates and Related Compounds" by S. R. Elsden and J. L. Peel is an outstanding contribution, particularly in its consideration of the energetics of anaerobic metabolism, discussing the breakdown of substrates from the point of view of the yield of adenosine triphosphate. The article also covers cellulose synthesis and breakdown, the breakdown of aromatic compounds, and tricarboxylic acid cycles. "Bacterial Genetics" by A. W. Ravin reviews advances on the mutation, replication, transfer and function of genetic material, and the contribution by A. Nason and H. Takahashi places recent studies on denitrification, nitrate utilization, nitrification and nitrogen fixation into perspective in the field of "Inorganic Nitrogen Metabolism".

"Bacterial Protoplasts" and "Bacterial Viruses" are dealt with by C. Weibull and W. Weidel, respectively, while L. Provasoli presents a thoughtful study of the relation between laboratory and field investigations in the "Nutrition and Ecology of Protozoa and Algae". The parasitic and pathogenicity aspects of microbiology are well catered for in this volume, which contains reviews on staphylococci, respiratory tract viruses, virus infection in plants, parasitic diseases in man, and the use of bacteria grown *in vivo* for studies on the basis of their pathogenicity. The control of infection is discussed in articles on antibiotics in plant disease, chemical disinfectants, and radiation preservation of food. P. Grabar provides a further summary, with 200 references, of recent Russian literature.

It can be seen that the present volume, containing nineteen articles and a grand total of 3,211 references, will find a place on the shelves of microbiologists, medical men and biochemists, all of whom will acknowledge their indebtedness to the editors and contributors for maintaining the high standard that we have come to expect of these "*Annual Reviews*".

TOPICS IN CARBOHYDRATE CHEMISTRY

Polysaccharides in Biology

Transactions of the Second Conference, April 25, 26 and 27, 1956, Princeton, N.J. Edited by Dr. George F. Springer. Pp. 245. (New York: Josiah Macy, Jr. Foundation, 1957.) 5 dollars.

THIS book gives a verbatim account of the transactions of a second conference, sponsored by the Josiah Macy, Jr. Foundation. It brought together a group of experts who discussed three topics in carbohydrate chemistry, namely: "Sialic Acid and Related Compounds"; "Interaction of Polysaccharides and Viruses"; and "Pyrogens". These topics are of the utmost importance in certain aspects of medicine at the present time, and the twenty-six experts were undoubtedly among the best that could be got together for the particular subjects. The method of reporting the conference, however, must be sharply criticized, because it can only be of value to the expert: even to the expert it is very irritating, but to the non-specialist it would be almost impossible to get anything of real significance out of the book. The whole thing is reported in a completely uncritical manner, and many comments of the experts, some of them mere interjections, are of no value. Perhaps the scientific editors will in future take a leaf out of the books of the Ciba Foundation and provide a substantial piece of well-thought-out writing on which to base the main conclusions of a topic: then comments by participants in the succeeding discussion will have more weight and will be more tangible.

The discussion on sialic acid and related compounds was led by Dr. F. Zilliken, and generally all that is known about this interesting group of substances up to 1956 was brought out either by direct communication or by discussion. The growing importance of this nonosaminic acid was well illus-

trated by the experiences of the participants in a number of fields.

The discussion of polysaccharides and viruses was led by Frank L. Horsfall, who was allowed to make at least a page and a half of contribution before he was interrupted by his fellows. It did emerge that the twenty or more viruses react in one way or another with erythrocytes. Many of them can cause hæmagglutination, a phenomenon which can be inhibited specifically by complex polysaccharides of the muco-protein class. Powerful inhibitors of viral hæmagglutination may be found in urine, egg-white, serum, and so on. The animal viruses may be divided into three groups: those which contain particles which react with the red cells, are absorbed, and then emerge again; others which contain components which react and are absorbed by the red cell but cannot be released; and the third group which does not attach itself to a red cell but produces a soluble substance that does attack the cell.

The discussions on the implications of these new interactions of polysaccharides and viruses components are intensely interesting. The discussion on pyrogens was led by Dr. O. Westphal, of the Wander Research Institute, Freiburg, Germany. Pyrogens are substances which, after injection in higher animals, promote a rise in body temperature. Among these are many polysaccharides, particularly those which are elaborated by bacteria. The problem of pyrogen production is, of course, of the greatest importance in medical treatment. Those discussed were of the lipo–polysaccharide–protein complex type. In this discussion masses of observations by the different participants were described and in one way or another almost all the constituents of Gram-negative bacteria have been brought in. The nature of the properdin system and its reaction with polysaccharides were well discussed and comparisons were made between properdin and antibody. In some cases these are well described in tables and diagrams, but they are very difficult to sort out in regard to their relative importance.

Excellent references are given, and to the expert, the whole of this discussion will be of the greatest value and interest. However, to make the book of wider appeal and the discussions of greater value in the future, it is to be hoped that the editor will make a critical assessment of those positive results which have emerged from discussion.

M. Stacey

POPULATION ECOLOGY

Animal Ecology To-Day

By Prof. F. S. Bodenheimer. (Monographiae Biologicae, Vol. 6.) Pp. 276. (Den Haag: Uitgeverij Dr. W. Junk, 1958.) n.p.

Cold Spring Harbor Symposia on Quantitative Biology

Vol. XXII: Population Studies—Animal Ecology and Demography. Pp. xiv+437. (Cold Spring Harbor, L.I.: Long Island Biological Association, 1957.) 8 dollars.

Bodenheimer's "Problems of Animal Ecology" (1938) has for some time been out of print. Although broader in scope, "Animal Ecology To-Day" is essentially a revision of the earlier book in the light of twenty years added experience. The central theme remains that "the principal aim of ecological research is to explore the fluctuation of populations and their (homologous) causes". From this point of view Bodenheimer discusses longevity (Chapter 1), life-history (2), population dynamics (3 and 4), the community (5), environment and heredity (6) in animals, and ends with a brief dissertation on human ecology (7). Many of the illustrations are from works unfamiliar to Western readers. As might be expected in a widely ranging treatise, a few sub-sections are not quite up to date.

"Animal Ecology To-Day" is truly, as the author says, "not written against anyone or against any theory" quoted or discussed. Nevertheless, it is still to a considerable extent a fairly strong testament of Bodenheimer's personal views. Naturally, he has changed some of the latter since 1938; for example, on the question of weather in population dynamics. At the same time, he is sometimes penetratingly critical of opposing views, as when he points out that parasites can be wrongly credited with controlling increase of their hosts (Fig. 17). This is not a book for beginners. It should be regarded as a thought-provoking supplement to text-books such as those of Allee *et al.* and Andrewartha and Birch. The mature ecologist will find much with which to agree and much with which to disagree. Where acceptable it is sometimes illuminating, and where unacceptable it is occasionally stimulating. Theorists, and those who do not readily distinguish between theory and fact, should profit by reading pp. 190–201.

For up-to-date comprehensive surveys, biologists the world over owe much to the organizers of the carefully edited and beautifully produced "Cold Spring Harbor Symposia". Vol. 22, on population studies, puts them still further in debt. No serious worker on population problems can afford to be without access to it. Containing thirty-six papers (with useful discussions of twenty-four), it is devoted about equally to human and animal populations. Many of the authors are well-known authorities in their subjects and about one-third are from outside the North American continent. Representation is well balanced with respect to controversial matters; for example, the question of natural control of animal populations. Beginning with a very capable introductory survey (containing, as seems to be inevitable, its author's own views at some length), the volume effectively covers most of the important aspects of population study—historical, theoretical, laboratory and field. One is still waiting, however, for geneticists to direct their attention from evolution to regulation of populations. Like all symposia (cp. "The Numbers of Man and Animals"), this volume has disjointed and ill-assorted features. One therefore admires the realism of the author of the "Conclusion", who soon abandons all pretence of summing up the proceedings and devotes most of his paper to expounding a particular view of his own. After all, no one could be expected to sum up proceedings on two subjects so different (despite some basic similarities) as human and animal populations, and including papers on aspects as diverse as "Farris' Formula for predicting Fertile Days" in women and "Roosting Habits, Sexual Dominance and Survival in the Great Tit". Future symposia should be on either human or animal populations, but not on both.

In animal ecology to-day there is less need for new books than for an international committee to define and standardize terms and concepts. Perusal of these two volumes makes this abundantly clear.

A. Milne

Hemophilia and Hemophilioid Diseases

International Symposium. Edited by Prof. Kenneth M. Brinkhous. Pp. xxii+265. (Chapel Hill, N.C.: University of North Carolina Press; London: Oxford University Press, 1957.) 60s. net.

IN August 1956 a symposium, sponsored by the National Hemophilia Foundation of the United States, was held in New York. About 125 persons attended, and among the 62 who read papers or contributed to the discussion were included a high proportion of the scientists and clinicians of the present day who have contributed most to the study of hæmophilia and allied disorders. The present book is a record of this meeting, consisting of 29 papers divided into seven main sections and verbatim reports on subsequent discussions. Most of the papers are illustrated by figures and most of them include adequate lists of references.

The papers are inevitably of uneven quality; some are short general summaries, others describe experiments in detail. One of the most interesting and controversial subjects discussed inconclusively at the symposium was the frequency with which anticoagulants or inhibitors are found in the plasma of hæmophiliacs and their importance in the pathogenesis of bleeding. The discussion at the end of each group of papers makes interesting reading, even if the questions asked and statements made often pose more questions than they answer.

A good example of a tantalizing statement is to be found at the foot of p. 62. In it R. J. Carroll states that hæmophiliacs are graded 1, 2, 3 and 4 on the basis of the anticoagulant content of their plasma and that the grade is constant for a particular patient. It need perhaps scarcely be added that there is still no uniformity of opinion as to whether anticoagulants really exist in hæmophilic plasma except on rare occasions.

This is a book for those who have a special interest in the hæmorrhagic disorders, whether they be physicians, clinical pathologists or medical scientists. It does not seem likely to have much appeal to workers outside this field. J. V. DACIE

Biological Aspects of the Transmission of Disease

Edited by C. Horton-Smith. (Reports of Symposia of the Institute of Biology.) Pp. ix+184. (Edinburgh and London: Oliver and Boyd, Ltd., 1957. Published for the Institute of Biology.) 21s. net.

"BIOLOGICAL Aspects of the Transmission of Disease" is the title of the proceedings of symposia organized by the Institute of Biology. It covers such a wide range of subjects that few reviewers would feel competent to do it justice. With the increasing specialization in all aspects of biology, it is very refreshing and most instructive to read accounts of problems of transmission of disease in fields or media totally different from those known to the reader.

As is inevitable in asking experts to write briefly on very complex subjects, one can find minor errors and ambiguity in places, but this does not really detract from the value of this kind of book in widening the field of interest and, one hopes, whetting the appetite of the reader to pursue further many original papers by the eminent contributors.

Unfortunately, it is a small book for a guinea.

C. W. DIXON

The Astronomer's Universe

By Prof. Bart J. Bok. Pp. xi+107+16 plates. (Melbourne: University of Melbourne Press; London: Cambridge University Press, 1958.) 21s. net.

THE author of this book, who was formerly on the staff of the Harvard Observatory, is now director of the Commonwealth Observatory and professor of astronomy in the Australian National Observatory. The book is based on four lectures delivered in Canberra, in which some account was given of the more important developments that have been made in recent years in our knowledge of the universe. The first of these lectures deals with some problems of the solar system, including the atmospheres of the planets, the origin of the system, and the Sun's corona. The second is concerned with some of the properties of stars as individuals and describes the two types of stellar populations found, respectively, in the spiral arms of galaxies, and in stellar clusters and galactic nuclei. The third lecture is concerned with the Milky Way system and summarizes the evidence for the existence of spiral arms from optical and radio observations. The final lecture is somewhat more speculative in character, discussing matters, such as the cosmic time-scale, stellar evolution, and the birth of stars, on which much evidence has been obtained in the past decade.

The book avoids technicalities and is well written. It will interest all who wish to know how astronomical ideas are tending in many important problems which still await definite solutions. The book, which was printed in Melbourne, is well produced and has reproductions of a number of stellar photographs, several of which were obtained at the Commonwealth Observatory. H. SPENCER JONES

Physical Acoustics and the Properties of Solids

By Dr. Warren P. Mason. (The Bell Telephone Laboratories Series.) Pp. xii+402. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 67s. 6d.

WORKERS in acoustics look forward eagerly to a new book from the pen of Dr. W. P. Mason, who brings to his writings the authority and experience of many years on the research staff of the Bell Telephone Laboratories. As head of mechanics research he is writing of his own work and that of his associates in the main, though with frequent comparison of the Bell methods with those of other laboratories. The title of the book is possibly a little misleading since the words "physical acoustics" are evidently to be taken in conjunction with the words that follow—the introduction gives, in fact, the basic theory only in reference to the propagation of sound waves in solids.

The experimental portion covers in four chapters the sources (mostly ultrasonic) which can be used for transmitting longitudinal or shear waves in bars, the method of determining the velocity and attenuation of the signals launched into them, together with industrial applications of these experiments, like the ultrasonic flaw detector and the soldering iron, for which British firms have gained credit.

Part 2 of the book will have most appeal to physicists, since it discusses the theory of transmission of these waves in terms of dislocations, grain boundary losses, and lattice vibrations with their relaxations. The general reader can, in fact, appreciate from this authoritative account the important part which acoustics is playing to-day in solid state physics. E. G. RICHARDSON

SOCIAL IMPLICATIONS OF MENDELISM VERSUS MICHURINISM

By A. QUINTANILHA

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THE rediscovery of Mendel's Laws in 1900 raised the greatest interest in the world of science. Such a great amount of knowledge on the behaviour of the chromosomes, in the somatic life as well as in the sexual reproduction of plants and animals, accumulated during the last twenty years of the nineteenth century that it was not difficult to find a perfect parallel between this behaviour, on one hand, and the transmission of hereditary units, on the other. Thus was born the chromosome theory of heredity, an eminently materialistic theory which tried to localize in material particles, along the chromosomes, the factors responsible for the transmission of those hereditary characters which follow Mendel's Laws.

However, the fact that the first Mendelian geneticists were essentially interested in the problem of transmission of hereditary characters, that is, in the phenomenon of permanence, throughout the generations, of characters already existent in the ancestors, caused a great number of biologists and a considerable part of public opinion to suspect that the geneticists of the then new school were anti-evolutionists and reactionaries. This suspicion was reinforced by the fact that Mendel was a Catholic priest; and, on the other hand, by the circumstance that the Mendelian geneticists did not accept the Lamarckian theory of the heredity of acquired characters.

But after the first years of confusion the situation became clearer. The new school of Mendelian genetics accepted, as a demonstrated fact, the doctrine of evolution; and, as all the experiments trying to demonstrate the heredity of acquired characters led to negative results, they looked for the explanation of evolution in spontaneous mutability and natural selection.

In 1935, Lysenko started a campaign, partly scientific and partly political, against Mendelian genetics. Using, and, in my view, abusing, the name of Michurin, who enjoyed great popular prestige in the U.S.S.R., Lysenko tried to create a new school of Soviet biology of a strong nationalistic and anti-Mendelian tendency.

Mendel's fundamental and most original idea is that there are independent units of heredity responsible for the transmission of those characters which follow mathematical laws. The followers of Mendel succeeded in demonstrating that such units really exist, and are material particles localized in the chromosomes.

The Michurinists, on the contrary, deny the existence of cellular organs responsible for the transmission of hereditary characters. Heredity, they say, is a function of the organism as a whole, and not of any one specific organ. In grafting, for example, the scion as well as the stock can transmit to one another hereditary characters by means of plastic substances. "The plastic substances", wrote Lysenko, "produced by the scion and the stock, possess the characters of the breed, are endowed with definite heredity just as the chromosomes, and just as any particle of the living body"[1].

The Michurinist theory seems to me, on this point, in complete disagreement with the coherent results of half a century of cytogenetic research. To deny the specific role of the chromosomes in transmission of those hereditary characters which obey Mendel's Laws would be as absurd as to deny the specific role of the chloroplasts in carbon assimilation in green plants.

But the most interesting aspect of the question is that Michurin himself was not a Michurinist in the same sense as Lysenko. He himself confesses: "Unfortunately, I at first was enthusiastic about Grell's ideas of those days concerning the acclimatization of the best foreign varieties by grafting them on to hardy wild plants. Much labour and time were lost on these erroneous experiments before I finally became convinced that the method was useless. Then, following the advice of Dr. Betling, I began to breed my own new local varieties of fruit-bearing plants from the seeds of superior quality fruits. But it soon became clear to me that I could not expect to accomplish much without artificially crossing local varieties of plants with the best foreign varieties, because it is difficult to obtain higher qualities from mediocre varieties. To achieve this, the fruit of one of the parent plants must possess better, outstanding qualities. Consequently, it was necessary to resort to hybridization"[2].

That is, while Michurin used the Lamarckian methods of progressive acclimatization of varieties from temperate climates to the hard conditions of central Russia, he had only failures. Then he started working as any plant breeder of the Mendelian school would, that is, crossing varieties highly resistant to cold with others from temperate climates, not resistant but producing fruits of outstanding quality, and selecting among the descendants those plants bearing a new and desirable association of characters. Michurin was then acting as if he accepted the Mendelian principle of the existence of independent hereditary units susceptible of being associated in new combinations. He was carrying out Mendelian plant breeding.

Moreover, the impression which one gets from reading Michurin's "Selected Works" and from his biography is that he was a modest man without any kind of pretension to create a new biological doctrine and without the aggressiveness characteristic of the writings of his disciple and admirer, Lysenko. His criticism of the Mendelian theories is, above all, the consequence of a deficient scientific education. As a self-taught man, Michurin must have met with enormous difficulties in access to works of reference, and it is highly probable that he never read Mendel's original work.

In an article published in 1925, in which he gives a summary of the results of half a century's work, he says: "In conclusion, I should like to note that in general, and in the brief résumé of my work in particular, I make no pretensions of having demonstrated new discoveries or having refuted any laws established by authorities in science.

"It is very probable that in some cases I may be wrong due to having erroneously interpreted various phenomena in the life of plants and the application

of, let us say, the laws of Mendel or other modern teachings to them; but such mistakes are inevitable in every work and they cannot be of much significance since they will in all probability be rectified by other investigators in the future"[3].

It is strange to notice that the Michurinists accept enthusiastically and with great praise Darwin's materialistic theory of evolution with the exception of its most original part, the principle of natural selection, as a consequence of the struggle for life, and the survival of the best adapted. Yet, strange though this may seem, it can be explained. Darwin himself confesses: "In October 1838, that is fifteen months after I had begun my systematic inquiry, I happened to read for amusement *Malthus on Population*, and, being well prepared to appreciate the struggle for existence which everywhere goes on from long continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved, and unfavourable ones to be destroyed . . . Here then I had at last got a theory by which to work"[4].

Now the work of Malthus was published for the first time in 1798 in an atmosphere of controversy. Against the socialist doctrine that misery is a consequence of a faulty social organization, Malthus tried to prove that, on the contrary, misery was the necessary consequence of a natural law, the law which rules the growth of population. When there are no obstacles, the human population, like those of other animals, tends to grow in geometric progression, while the means of subsistence grow in arithmetic progression.

Misery in the last analysis is the unavoidable consequence of this disproportion, of this 'natural law'. Great famines, wars, epidemics, social or natural cataclysms are so many other means which re-establish automatically a certain equilibrium between the number of mouths and the possibility of feeding them.

Social reforms, raising the standard of living of the poorer classes, far from solving the fundamental problem, may even help to aggravate the situation; as a matter of fact, stimulating the birth-rate of the working classes by a temporary increase in their well-being may create in this way a greater future discrepancy between the population and the means of subsistence.

For Malthus the problem is not a social one, and it is not possible to solve it by re-organizing human society on different bases. The only solution would be the exercise of 'moral restraint'—abstention from marriage for poor people who could not feed and educate their families, and the practice of conjugal continence for married people in similar conditions.

The application of Malthusian principles to animals and plants allowed Darwin to find an explanation of evolution, that is, the appearance of new species derived from pre-existent ones. An unavoidable consequence of the population law is the struggle for life, for breathing space and means of subsistence between individuals of the same species. As soon as the species covers a sufficiently large area, in each place there will be greater probability of survival for individuals bearing variations which make them better adapted to the local conditions. From this arises the tendency for the formation, inside the species and in different ecological areas, of nuclei of populations with different hereditary characters, each of which is the possible starting point for the formation of a new species.

During the nineteenth century, economists and sociologists tried to use Malthus's doctrine against socialist propaganda. In the same way Darwin's theory of the struggle for life and the survival of the fittest was used to justify the existence of human societies divided into classes with different functions and different rights.

Competition, the struggle for life among individuals of the same species, would be in this way a natural law from which human society could not escape. Just as in other animal societies, the struggle for life among human beings would lead to the success of the fittest. It would then be quite in order to give the upper classes functions of direction. Misery, hunger, unemployment are not only unavoidable consequences of biological laws; but in their way they contribute to the slowing-down of procreation in the worst-adapted classes of society.

It is not difficult to understand the violence of the reaction in socialist circles, not only against Malthus's doctrine on population, but also against the political-social consequences which sociologists pretended to deduce from Malthus's and Darwin's doctrines.

Karl Marx, in his famous book "Das Kapital", attacked Malthus sharply and asserted that an abstract law of population can only exist for plants and animals. In human societies a particular law of population corresponds to each type of social organization of production. In the capitalist society of the nineteenth century, the limiting factor in population increase was the possibility of obtaining work. The working classes were permanently under the menace of unemployment crises, an unavoidable consequence of a social organization which produced not for consumption but for sale.

Engels's reaction was not less violent, and extended to the consequences which, in reactionary circles, they pretended to deduce from Darwin's doctrines. In a letter published in 1875 he wrote: "The entire Darwinian teaching on the struggle for existence merely transfers from society to the realm of living nature Hobbes' teaching on *bellum omnium contra omnes* and the bourgeois economic teaching on competition, along with Malthus' population theory. After this trick (the absolute justification for which, as indicated in point 1, I deny, particularly in regard to Malthus' theory) has been performed, the same theories are transferred back from organic nature to history and the claim is then made that it has been proved that they have the force of eternal laws of human society. The childishness of this procedure is obvious, and it is not worth while wasting words on it. But if I were to dwell on this at greater length, I should have started out by showing that they are poor economists first, and only then that they are poor naturalists and philosophers"[5].

Kautsky accepted the Malthusian principle that human populations, like animal ones, *tend* to grow quicker than the amount of available food. But, like Marx, he directed attention to the circumstances that, in capitalist societies, what limits the production is the antagonism of interests between the proprietors and the workers. Once this antagonism disappears through the advent of socialism, the production of means of subsistence will be able to increase in unprecedented proportions. But, according to Kautsky, this will not yet solve the problem, because the tendency of a more rapid increase in population than in the means of subsistence will remain. The solution, however, is not in the abstention from marriage nor in the practice of continence, as Malthus

preached, but in a future birth-control. Already in 1880 Kautsky foresaw that birth-control would be more and more used as the cultural level of human society rose.

The solution of the tragic problem posed by Malthus at the end of the eighteenth century is then, for Kautsky, in the advent of socialism and in the practice of birth-control.

Another great socialist who wrote widely about the problem was Kropotkin. In his book "Mutual Aid as a Factor of Evolution", Kropotkin tried to demonstrate that, besides the struggle for life among individuals of the same species, another factor of evolution exists, namely, mutual aid. In animal populations, as soon as social life becomes intensified, there develops a spirit of co-operation and solidarity. The struggle of one against all for the means of subsistence tends to be little by little replaced by the struggle of all the individuals of the same society against their common enemies and against adverse natural conditions.

As soon as animals start to live in societies a new factor intervenes in natural selection, namely, the instinct of sociability (gregariousness). Within each species Nature will select those individuals in which this instinct is most highly developed. In inter-specific competition, those species in which social life is best organized will have greater chances of success.

Many other socialist leaders took an active part in the controversy which arose around the thesis put forward by Malthus and the social consequences which many sociologists pretended to take from his doctrines and from that part of Darwin's theory of Malthusian origin.

Now we can understand better the attitude of the Michurinists who, imbued with an out-of-date Marxism, were never able to understand that the admission of the existence of a struggle for life between individuals of the same species, in the plant and animal kingdoms, does not in any way justify the social consequences which the opponents of socialism pretend to deduce against the socialist doctrine.

In the plant kingdom and in a great number of animal species the struggle for life, even among individuals of the same species, is a biological fact so evident that it seems to me difficult to deny it. But already in many animal species, as soon as a social life starts, this struggle begins to be gradually replaced by co-operation between the members of the same community against their external enemies and the adverse conditions of Nature: and who would be better placed than the Russian biologists to assert that, in human societies, it is possible and advantageous to replace the principle of competition between individuals of the same community by the principles of co-operation and mutual aid?

Modern history proved the correctness of the socialist leaders' predictions in the Malthusian controversy. In modern human societies the reproduction-rate decreases, in spite of the spectacular decrease in mortality, with the increase in their cultural level. Deliberate birth-control tends, therefore, to establish an automatic balance between the number of mouths to be fed and the possibility of feeding them. On the other hand, the advent of socialism and consequent disappearance of antagonistic class interests has shown the possibility of developing agricultural and industrial production, even in backward countries, in a way without precedent in human history.

The rejection by the Michurinists of the Darwinian doctrine of the struggle for life as a factor of evolution is, in my opinion, the consequence of a social–political prejudice, the erroneous conviction of the incompatibility between that doctrine and the socialist ideal of a classless society based on the principle of co-operation.

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DENSITY OF THE ATMOSPHERE AT HEIGHTS BETWEEN 200 KM. AND 400 KM., FROM ANALYSIS OF ARTIFICIAL SATELLITE ORBITS

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THE action of atmospheric drag makes the orbit of an Earth satellite slowly contract, and its period of revolution T decrease. When the eccentricity of the orbit exceeds about 0·02, the drag at perigee is much greater than at apogee, and the rate of decrease of T is determined by the total loss in velocity due to the integrated effect of drag in the region near perigee. If the mass and dimensions of the satellite are known, and estimates are made of its aerodynamic drag, values of air density at heights near perigee can be obtained.

Such estimates of air density have been made in a number of previous papers[1–11]. Since the effective cross-sectional areas and drag coefficients of the satellites are difficult to determine exactly, the various authors have inevitably made different estimates of these quantities. Also most of the previous papers refer to only one or two satellites. In the present article, values of density are derived from all the ten satellites launched up to the end of 1958 whose orbits are known, the satellites are treated consistently, and a more accurate method of determining density is used.

Previous Estimates

The results from the previous papers[1–11], and values[12] obtained from instruments aboard *Sputnik* 3 (1958 δ 2), are collected in Fig. 1, together with two proposed interim model atmospheres[2,13] and the A.R.D.C. model atmosphere[14], which was probably the most widely used standard atmosphere in the year prior to satellite launchings. As is well known, the results from satellites show the density in the

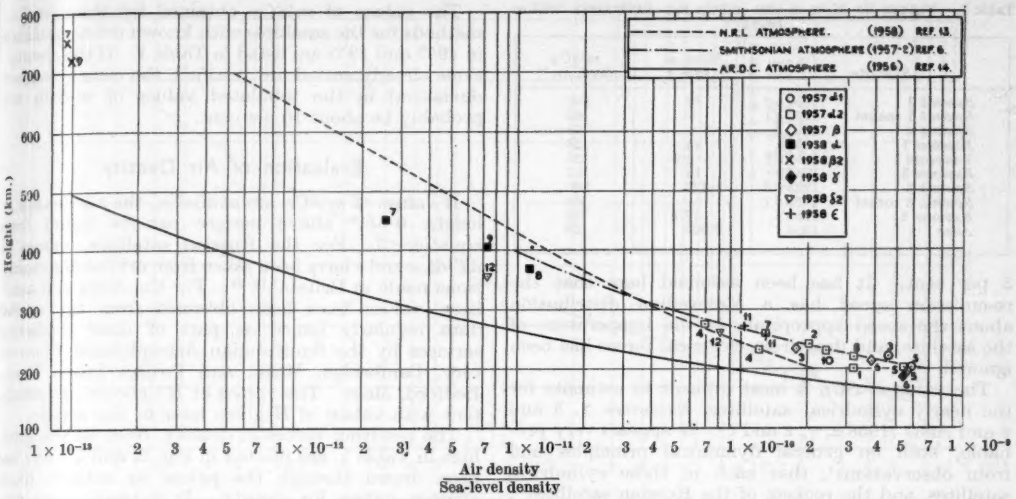

Fig. 1. Values of air density obtained by means of satellites (refs. 1–12), with proposed 'standard atmospheres' (refs. 6, 13, 14). Reference numbers are shown beside the plotted points

200–400 km. height range to be 5–15 times greater than indicated by the A.R.D.C. model. In Fig. 1, the abscissa is the density relative to sea level, the sea-level density being taken as 1·23 kgm./m.³ or 0·0765 lb./cu. ft. The scatter of the points in Fig. 1 is not significant, since it could be due to the different methods and assumptions of the different investigators.

Present Method of Analysis

It is customary to express the air drag D encountered by a body moving with velocity v in air of density ρ in terms of a drag coefficient C_D as :

$$D = \tfrac{1}{2}\rho v^2 SC_D \qquad (1)$$

where S is a reference area, which may here be taken as the mean cross-section of the satellite perpendicular to the direction of motion. If a satellite of mass m is in an orbit with semi-major axis a and eccentricity e between 0·015 and 0·15, the air density at perigee, ρ_p, can be expressed[5,15] as :

$$\rho_p = -\frac{\mathrm{d}T}{\mathrm{d}t}\frac{m}{3SC_D}\sqrt{\frac{2e}{\pi aH}}\left\{1 - 2e - \frac{H}{8ae} + 0\left(e^2, \frac{H^2}{a^2e^2}\right)\right\} \qquad (2)$$

where $\mathrm{d}T/\mathrm{d}t$ is the rate of change of the period of revolution T, which can be determined accurately from observation. In deriving equation 2, it is assumed that, above perigee height y_p, the density of the air varies exponentially with height, the density ρ at height y ($> y_p$) being given by :

$$\rho = \rho_p \exp\left\{-\frac{y - y_p}{H}\right\} \qquad (3)$$

where H is constant. Since the value of H is not accurately known at heights of 200–400 km., equation 2, though it determines $\rho_p\sqrt{H}$ with little error, does not yield an accurate value of ρ_p.

This limitation can, however, be avoided. Let H^* be the best estimate of H. Then the density at height $y_p + 0{\cdot}5H^*$ may, by means of equations 3 and 2, be expressed as :

$$\rho_{p+0{\cdot}5H^*} = \rho_p \exp\left(-\frac{H^*}{2H}\right) = -\frac{\mathrm{d}T}{\mathrm{d}t}\frac{m}{3SC_D}\sqrt{\frac{2e}{\pi aH^*}}\left[\sqrt{\frac{H^*}{H}}\exp\left(-\frac{H^*}{2H}\right)\right]\left\{1 - 2e - \frac{H^*}{8ae} + 0\left(e^2, \frac{H^2}{a^2e^2}\right)\right\} \qquad (4)$$

The function in square brackets is insensitive to the value of H^*/H, and may be taken as 0·593, with error less than 2·5 per cent, if the estimated value H^* does not differ from the true value H by a factor of more than 1·5. Since H is usually known to within a factor of 1·5, and since the likely error in m/SC_D is as a rule appreciably greater than 2·5 per cent, it is legitimate to replace the term in square brackets in equation 4 by this constant, so that (4) becomes :

$$\rho_{p+0{\cdot}5H^*} = -\frac{0{\cdot}158\,m}{SC_D}\frac{\mathrm{d}T}{\mathrm{d}t}\sqrt{\frac{e}{aH^*}}\left\{1 - 2e - \frac{H^*}{8ae} + 0\left(e^2, \frac{H^2}{a^2e^2}\right)\right\} \qquad (5)$$

The error arising from neglect of terms in e^2 and H^2/a^2e^2 is less than 3·5 per cent if $0{\cdot}015 < e < 0{\cdot}15$. The use of equation 5 to obtain the density at height $0{\cdot}5H^*$ above perigee should not lead to errors of more than 4·5 per cent if H^* is not in error by a factor of more than 1·5. If H^* is in error by a factor of 2, the error in equation 5 rises to 12 per cent.

Evaluation of m/SC_D

In applying equation 5 to actual satellites, the chief difficulty is the evaluation of SC_D. Its value depends on the shape of the satellite, the manner in which it is rotating, and the mechanism of reflexion of the air molecules. Diffuse reflexion, in which the air molecules are re-emitted in a random manner after striking the surface, has been chosen as the most likely mechanism, in preference to specular reflexion, in which the molecules are reflected as if from a mirror. Though there is scope for argument about the speed of re-emission of the molecules in diffuse reflexion, the drag coefficients obtained under the various possible assumptions do not differ by more than about

Table 1. Values of Mass m and m/SC_D for Satellites 1957 α–1958 ζ

Satellite		Mass, m (kgm.)	m/SC_D (kgm./m.²)
Sputnik 1	1957 α 2	83	110
Sputnik 1 rocket	1957 α 1	—	62
Sputnik 2	1957 β	—	58
Explorer 1	1958 α	14	23
Vanguard 1	1958 β 2	1·5	23
Explorer 3	1958 γ	14	23
Sputnik 3	1958 δ 2	1,327	190
Sputnik 3 rocket	1958 δ 1	—	59
Explorer 4	1958 ε	17·5	29
Atlas	1958 ζ	3,960	28

5 per cent. It has been assumed here that the re-emission speed has a Maxwellian distribution about the speed appropriate to the temperature of the satellite, and drag from electrical forces has been ignored.

The value of SC_D is most difficult to estimate for the nearly cylindrical satellites, *Explorers* 1, 3 and 4 and *Atlas* (1958 α, γ, ε and ζ). It appears very probable, both on general dynamical principles and from observations[7], that each of these cylindrical satellites, and the rockets of the Russian satellites[10], have rotated about their axis of maximum moment of inertia, that is, an axis perpendicular to their length, though the angle between this axis of rotation and the direction of motion has varied. If this picture is correct, the two extreme modes of rotation are (*a*) travelling exactly like an aeroplane propeller, and (*b*) tumbling end-over-end. In (*a*), the axis of spin and the direction of motion are parallel; in (*b*), they are at right angles; and in practice the angle may be anywhere between these extremes. A recent study (G. E. Cook, unpublished work) has shown that, under the assumption of diffuse reflexion, a rotating cylinder of length l and diameter d ($d \sim 0{\cdot}1\ l$) has a value of SC_D of about $2{\cdot}2\ ld$ under regime (*a*) and about $1{\cdot}5\ ld$ under regime (*b*). For any motion between these extremes, SC_D lies between $1{\cdot}5\ ld$ and $2{\cdot}2\ ld$. The nearly cylindrical satellites have been treated here as cylinders, with SC_D taken as $1{\cdot}85\ ld$, the mean of the values under regimes (*a*) and (*b*). If each satellite has rotated about its axis of maximum moment of inertia, this value of SC_D will not be in error by more than 19 per cent.

The spherical satellites *Sputnik* 1 and *Vanguard* 1 (1957 α 2 and 1958 β 2) both have cylindrical antennæ, and their drag coefficient C_D has been taken as 2·2, with S as the mean cross-section during one rotation. This value should not be in error by more than 5 per cent, since $C_D \simeq 2{\cdot}1$ for a sphere and $C_D \simeq 2{\cdot}2$ for a rotating cylinder. For the conical *Sputnik* 3 (1958 δ 2), S has been taken as the mean of the cross-sections in modes of rotation (*a*) and (*b*), with $C_D = 2{\cdot}3$. For *Sputnik* 2 (1957 β), no weights and dimensions are available, but the value of m/SC_D can be inferred from *Sputnik* 1. Since the perigee heights of *Sputniks* 1 and 2 were virtually the same[10], equation (2) gives:

$$\left(\frac{m}{SC_D}\right)_2 = \left(\frac{m}{SC_D}\right)_1 \sqrt{\frac{a_2 e_1}{a_1 e_2}} \left(\frac{dT}{dt}\right)_1 \Big/ \left(\frac{dT}{dt}\right)_2 \qquad (6)$$

where suffixes 1 and 2 refer to *Sputniks* 1 and 2, respectively. Since the factors on the right-hand side of (6) are known, $(m/SC_D)_2$ can be found. Values of m/SC_D for the rockets of *Sputniks* 1 and 3 (1957 α 1 and 1958 δ 1) can be found similarly. This indirect method should be reliable if, as is believed[16,17], each of the satellites 1957 α 1, 1957 β and 1958 δ 1 retained a virtually constant value of m/SC_D until the last day of its life.

The values of m/SC_D obtained by these various methods for the satellites with known orbits launched in 1957 and 1958 are listed in Table 1. If the assumptions already stated are justified, the error (standard deviation) in the tabulated values of m/SC_D will probably be about 10 per cent.

Evaluation of Air Density

If values of m/SC_D are available, the air density at height $0{\cdot}5H^*$ above perigee can be found from equation 5. For the Russian satellites, values of dT/dt, a and ε have been taken from orbital determinations made in Britain[2,18–20]. For the American satellites, values have been obtained from the orbital data regularly issued as part of their prediction services by the Smithsonian Astrophysical Observatory, Cambridge, Mass., and Project Space Track, Bedford, Mass. The values of H^* chosen are consistent with values of H given later in this article.

The resulting values of density, from all the satellites in Table 1, are plotted in Fig. 2, and a curve has been drawn through the points to indicate likely average values for density. It is usual when constructing a 'model atmosphere' to make a plausible assumption about the variation of temperature and air composition with height, and thence derive density. Since the primary measurements are of density, however, it seems more logical to take the density as the basic parameter and then to deduce temperature from it. This procedure has the further merit that it shows the large errors in temperature which can arise, even when a good fit is achieved for the density.

Several features of Fig. 2 are worth noting:

(1) The ten different satellites give surprisingly consistent values of air density. None of the 15 plotted points in the cluster between 190 km. and 260 km. differs from the curve by a factor greater than 1·4, and the average factor of difference is about 1·2. Probably, therefore, the assumptions made were not grossly in error, as they would have been if, for example, one of the cylindrical satellites had flown like an arrow instead of rotating.

(2) Even if the method of analysis were perfectly accurate, the points in Fig. 2 would not all lie on the same curve, since the effective air density is known to vary from day to day and month to month, by up to 30 per cent at 200–250 km. height[16,17] and by a factor of 3 at 700 km. (ref. 21). The curve in Fig. 2 can therefore only represent average values.

(3) The points in Fig. 2 cover latitudes between 50° N. and 35° S.; but there is no sign of any regular variation with latitude, and the spread of the points suggests that, between 50° N. and 35° S., density does not depart from its average value by a factor of more than about 1·5. This is in contrast with results from rocket experiments[22], which suggest a variation by a factor of up to 5 between 59° N. and 33° N. on a summer day. The accuracy of initial estimates of life-time for the Russian satellites, the perigees of which moved from an initial latitude near 50° N towards the equator, also suggests that density does not vary greatly within this range of latitude.

(4) The one point above 400 km. in Fig. 2 should not be taken seriously, partly because it is unsupported and partly because the effect of charged drag[23] is likely to be important at 700 km., where more than 5 per cent of the atoms may be ionized.

Table 2 lists values of average density from the curve in Fig. 2, for heights between 200 and 400 km., where the error-factor should not exceed 1·5.

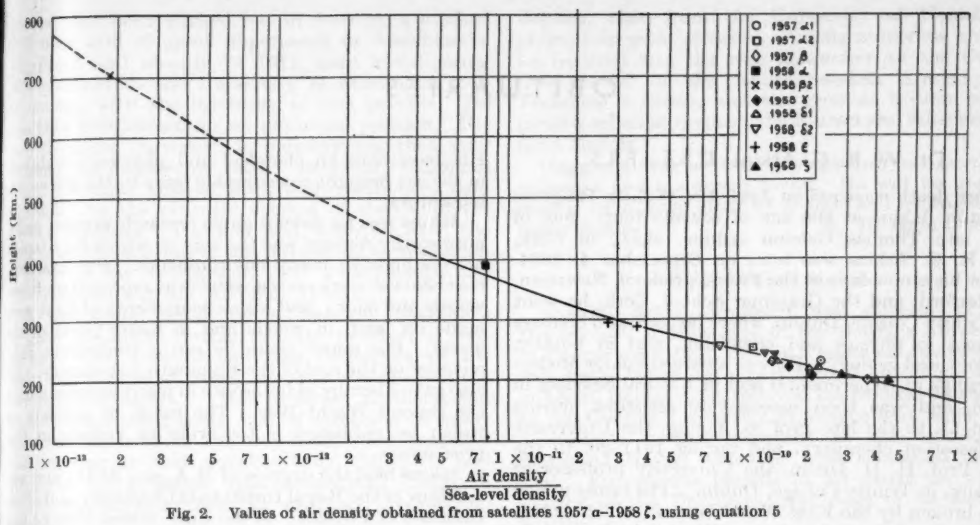

Fig. 2. Values of air density obtained from satellites 1957 α–1958 ζ, using equation 5

The air temperature should, in theory, be obtainable from the slope of the curve in Fig. 2; but in practice the accuracy is poor. Values of the coefficient H of equation 3 derived from the slope of the curve in Fig. 2 rise from $H = 37$ km. at 200 km. height to $H = 71$ km. at 400 km. height. But it is possible to link the points in Fig. 2 with other curves, of different slopes. For example, a straight line between 200 and 400 km. height, with $H = 50$ km., fits the points almost as well. There are other ways of finding H, the most direct being to use the equation connecting eccentricity e with perigee distance from the centre of the Earth, r_p. The appropriate expression for H, accurate to $\pm$ 5 per cent if $0{\cdot}015 < e < 0{\cdot}2$, is found (D. G. King-Hele and G. E. Cook, unpublished work) to be:

$$H = \frac{r_{p_0} - r_p}{\frac{1}{2}\ln\left\{\frac{ae}{a_0e_0}\left(\frac{8a_0e_0 - 3H}{8ae - 3H}\right)^2\right\}} - \frac{a_0e_0 - ae}{a_0} \qquad (7)$$

where zero suffix denotes initial values. This equation, like equation 2, is not significantly altered by the effect of the oblateness of the Earth. The value of H obtained from equation 7, using kinetheodolite observations of *Sputnik* 2, is $H \simeq 55$ km. at 200 km. height. It is, at present, difficult to choose between these rather scattered values of H. It seems probable however that, at heights between 200 and 400 km., the average value of H is near 50 km., and that H tends to increase with height. If a value had to be chosen, H might be assumed to rise from 45 km. at 200 km. height to 60 km. at 400 km. height, with an error-factor which should not exceed 1·5.

Table 2. Average Air Density at Heights between 200 km. and 400 km.

Height (km.)	Air density / Sea-level density	Density (gm./c.c.)
200	$3{\cdot}4 \times 10^{-13}$	$4{\cdot}1 \times 10^{-13}$
220	$2{\cdot}0 \times 10^{-13}$	$2{\cdot}5 \times 10^{-13}$
240	$1{\cdot}2 \times 10^{-13}$	$1{\cdot}5 \times 10^{-13}$
260	$7{\cdot}6 \times 10^{-14}$	$9{\cdot}3 \times 10^{-14}$
280	$4{\cdot}6 \times 10^{-14}$	$5{\cdot}6 \times 10^{-14}$
300	$2{\cdot}9 \times 10^{-14}$	$3{\cdot}6 \times 10^{-14}$
320	$2{\cdot}0 \times 10^{-14}$	$2{\cdot}4 \times 10^{-14}$
340	$1{\cdot}4 \times 10^{-14}$	$1{\cdot}7 \times 10^{-14}$
360	$9{\cdot}7 \times 10^{-15}$	$1{\cdot}2 \times 10^{-14}$
380	$7{\cdot}1 \times 10^{-15}$	$8{\cdot}7 \times 10^{-15}$
400	$5{\cdot}3 \times 10^{-15}$	$6{\cdot}5 \times 10^{-15}$

At heights between 200 and 400 km., the air temperature in degrees Kelvin may be expressed approximately as $1{\cdot}1\,MH/(1 - H')$, where M is the molecular weight of the air, H is in kilometres, and H' is the rate of change of H with height. The main constituents of the air at these heights are believed to be atomic oxygen and atomic nitrogen, in proportions as yet unknown[13,24–26]. If, then, M is taken as 15 and $H' \simeq 0{\cdot}07$, the average temperature between 200 and 400 km. height will be about 1,000° K. It should be emphasized, however, that any values of temperature are far less reliable than values of density.

I wish to thank Mrs. D. M. C. Walker for preparing the graphs in this article.

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OBITUARIES

Dr. W. R. G. Atkins, C.B.E., F.R.S.

The death occurred on April 4 of William Ringrose Gelston Atkins at the age of seventy-four. Son of the late Thomas Gelston Atkins, M.D., of Cork, W. R. G. Atkins was born on September 4, 1884. After his schooldays at the Friend's School, Newtown, Waterford, and the Grammar School, Cork, he went to Trinity College, Dublin, where he took two honours degrees in physics and chemistry, and in botany, zoology and geology. He was awarded Senior Moderatorships in Experimental and in Natural Sciences in 1906, and was then successively assistant, during 1906–11, to the late Prof. S. Young, the University professor of chemistry, and during 1911–20, to the late Prof. H. H. Dixon, the University professor of botany, in Trinity College, Dublin. The latter period was broken by the First World War, in which Atkins was an assistant chemist at Woolwich Arsenal in 1915 and a volunteer assistant in the Division for Aeronautical Chemistry of the National Physical Laboratory for the first six months of 1916. As a result of his work at the National Physical Laboratory, he was given a commission as equipment officer in the Royal Flying Corps to organize and direct a laboratory in the Experimental Aircraft Establishment at the Aboukir Depot in Egypt, reaching the rank of major in the Royal Flying Corps. After the War he went for a short time as indigo research botanist at the Imperial Department of Agriculture in India.

In 1921, Atkins was appointed head of the Department of General Physiology at the Plymouth Laboratory of the Marine Biological Association, where he remained until his retirement in 1955, apart from the years of the Second World War, when he served successively in the Home Guard, the Royal Army Medical Corps, and the Meteorological Office.

Atkins's research work thus falls into two distinct periods, that at Trinity College, Dublin, and that at Plymouth. During the first period it was mainly physico-chemical, including such subjects as the properties of urine and the osmotic pressures of blood and eggs of birds, and of plant tissues. While in Egypt he was specially concerned with the deterioration of fabrics and the study of lubricants. In 1916, he published a book entitled "Some Recent Researches in Plant Physiology".

On his arrival at Plymouth Atkins thus had a very wide background on which to draw for his new field of research, which was the physical and chemical conditions of sea water as an environment for marine life. During his long period at Plymouth he undertook researches, the results of which are now basic to all modern research on the productivity of the sea and have passed into essential background knowledge. These related chiefly to the seasonal variations in the chemical conditions, especially the nutrient salts, in sea water; and to the penetration of light into the sea and the effects of fine particles in suspension. In the latter field Atkins collaborated with Dr. H. H. Poole, of the Royal Dublin Society. As a side-line, Atkins continued work started in Egypt on the deterioration of fabrics, in this instance experimenting on methods of preservation of nets and ropes. His researches on chemical and physical conditions in the sea brought considerable fame to the Plymouth laboratory.

Atkins was an indefatigable research worker, and a noteworthy feature was the way in which he adapted his methods to many environments. For example, his chemical work on sea water was repeated on freshwaters and soils; and his measurements of light were made on land, in woods and in many parts of the world. For many years he ran a continuous light recorder on the roof of the Plymouth Laboratory. He also gave liberally of his advice in many spheres during the Second World War. The range of subjects on which he published is too wide to include in this brief notice.

Atkins held the degrees of M.A. and Sc.D., and was a Fellow of the Royal Institute of Chemistry and of the Institute of Physics; in the First World War he was twice mentioned in dispatches and was awarded the O.B.E. (Mil.) in 1919. He was elected a Fellow of the Royal Society in 1925, and in 1928 he received the Boyle Medal of the Royal Dublin Society. In 1951 he was appointed a Commander of the British Empire in the King's Birthday Honours. He was president of Section K (Botany) of the British Association for this year's meeting in York.

In his earlier days at Trinity College Atkins was an athlete, and besides playing hockey and rowing at Trinity College, he was especially noted for his boxing. He became middle-weight champion of Ireland.

A man of great integrity and kindness, he had very many friends from all parts of the world, to whom he and his wife extended much hospitality at their home at Antony in Cornwall. To Mrs. Atkins, and their married son, all who knew him will extend their sympathy.

F. S. Russell

Prof. Erik Hägglund

Erik Hägglund died in Stockholm on March 13 at the age of seventy-one. His life was dedicated to the elucidation of the involved reactions in processing wood into cellulose and paper, more particularly the chemistry of the sulphite pulping process, its technology, and the nature of lignin and its secondary derivatives.

Hägglund obtained his scientific education at the University of Stockholm, being fortunate to come under the guidance of an inspiring teacher, Hans von Euler. He received his doctorate in 1914, presenting a thesis on the effect of *p*H on alcoholic fermentation. It is one of the very first critical investigations of modern type on hydrogen ion concentration. By the way, Hägglund was the first of von Euler's research students to become the incumbent of a university chair in chemistry among the twelve future professors who emerged from the Euler fold. Hägglund graduated three months before the outbreak of the First World War, during which research and chemical technology were given a potent impetus for the sake of national economy and feeding of the people. A few years earlier, the method of fermenting the sugars of waste liquor from the sulphite-pulping

process had been worked out in Sweden, a method still used and of great importance in Scandinavia. Hägglund had already, in 1911, been investigating this problem at the University of Stockholm, collaborating with the inventors of this process. He was thus predestined for an industrial position. The step from the university to industry was then very unusual, in Sweden at least. However, Hägglund found his right field of work and contributed substantially to the ultimate success of the 'sulphite–alcohol' venture. The first and, even by now, the only scientific account of this interesting fermentation is given in his monograph, "Die Sulfitablauge und ihre Verarbeitung auf Alkohol" (1921).

It was quite logical for a man of Hägglund's acumen to inquire further into the problem of converting wood into alcohol—the hydrolysis of the main constituent of wood, the cellulose—to produce fermentable sugars. This difficult problem had already received a great deal of attention in many quarters, but in vain. The only technique of practical use existing is that developed by Hägglund and Bergius, the so-called Rheinau-method (1917) in which hydrochloric acid is used as hydrolysing agent.

The great ability of this young scientist in solving intricate technical problems by application of fundamentals was early recognized in academic circles. In 1920, Hägglund accepted the chair of the chemistry of wood products especially established for him at Åbo Akademi, the Swedish-language university of the new Republic of Finland. A flourishing school of cellulose research came into being, the research output became formidable and many of the fundamentals of the speciality established. Hägglund's work formed a continuation of that of the grand old man of lignin chemistry, Peter Klason, emeritus professor of chemical technology in the Royal Institute of Technology in Stockholm. Actually, Hägglund became the spiritual successor to Klason in 1930, when a chair in wood chemistry and technology was founded at the Royal Institute, through donations from the pulp and paper industries. Fourteen years later, the Swedish Government erected an institute for pulp and paper research, probably the largest and best equipped institute of its kind at that time, constituting a unit of the Royal Institute.

Hägglund and his many pupils—of whom quite a number occupy leading positions in this key-industry of Sweden at the present time—have, during the past twenty-five years, investigated practically every phase of the wood-pulping processes and paper making. Work of a fundamental theoretical nature as well as important contributions to technological aspects of this industry, which is, of course, of great importance for Sweden, have emanated from the Hägglund school. Among his numerous co-workers, Adler, Enkvist, Erdtman, Giertz and Johnson were prominent. It is generally conceded that Hägglund did more than any other single individual to unravel the intricacies of the 'cooking' processes—his research on the formation of lignosulphonic acids being particularly outstanding. His comprehensive text-books, "Holzchemie" (1928, 1939), "Natronzellstoff" (1926) and "The Chemistry of Wood" (1951), are standard works throughout the world.

His unflagging endeavour in furthering the progress and well-being of the industry to which Hägglund devoted his life gave him an international standing. He was a member of many learned societies at home and abroad and received several honorary degrees, that from the University of Heidelberg giving him great pleasure. Among numerous awards he received was the rare distinction of the Grand Gold Medal of the Royal Swedish Academy of Technical Sciences, and the greatest honour to be given a cellulose chemist, the Ekman and Mitscherlich Gold Medals.

Hägglund was a sterling character, an inspiring colleague and a staunch friend. He will be greatly missed by a large circle of friends and colleagues in many lands.

K. H. Gustavson

Prof. Alfred Kohn

Alfred Kohn, professor and director of the Department of Histology of the German University in Prague until 1937, died in Prague on January 15, five weeks before his ninety-second birthday. Born in Libin, Bohemia, he received his medical education at the German University in Prague and, while still a student, became assistant to the histologist, Siegmund Mayer, whom he later succeeded in the chair. For various periods in his career he was a senator of the University and dean of its medical faculty.

Kohn is famous for his work on the parathyroids, which he termed *Epithelkörperchen*. His contribution was to point out clearly their independence of the thyroid. He was, at least, a silent partner in Gudernatsch's discovery, made in Kohn's institute, that feeding thyroid to tadpoles inhibits their growth but accelerates metamorphosis. His best-known work deals with the paraganglia and the chromaffin system, which terms he introduced. There has been much dispute about the nature of paraganglionic cells, but recent electron microscopical investigations bear out his views. Kohn considered chromaffin cells to be a special category, comparable with epithelium, nerve cells, muscle cells and so forth. They form a link between nervous and endocrine systems. Kohn also made significant contributions to our knowledge of the differentiation of the peripheral nervous system, stressing the early differentiation of nerve cells (*"primogenitur"*, *Hauptzellen*) and the later differentiation of Schwann cells, paraganglia and suprarenal medulla (*"secundogenitur"*, *Nebenzellen*).

I worked with him for ten years, and in my view Kohn should be considered a great clarifier who put into focus many structures and problems then only vaguely known or misinterpreted.

During the Nazi occupation of Prague, it seems that some informal protection was first extended to him, but when a *Diener* of the German Anatomy Department saw Prof. Grosser, the well-known embryologist, talk to the Jew, Kohn, in the street, the seventy-four year old Kohn was deported to a concentration camp. He returned to Prague in 1945, but he met new difficulties: on account of his German education and his position in the abolished German University, he was deprived of his superannuation; however, following protest in the Czech Press, it was restored. Later, the Communist government bestowed on this entirely unpolitical scientist the Order of Labour, which carries a supplemental income, thus making comfortable the last years of his life. Max Watzka, who succeeded him in Prague and is now editor of the *Anatomische Anzeiger* and professor of histology in Mainz, is, of all Kohn's disciples, the one who continues most consistently the work of Alfred Kohn.

Rudolf Altschul

NEWS and VIEWS

The Royal Society : New Foreign Members

The following have been elected foreign members of the Royal Society : Prof. Melvin Calvin, University of California, Berkeley, California, distinguished for his researches into the mechanism of photosynthesis ; Prof. Gerhard Domagk, University of Münster, director of the Research Laboratories for Experimental Pathology and Bacteriology, Farbenfabriken Bayer, Wuppertal-Elberfeld, Germany, distinguished for his researches leading to the discovery of 'Prontosil', the first chemotherapeutic agent against septic infection ; Prof. Jan Hendrick Oort, State University of Leyden, The Netherlands, distinguished for his contributions to the knowledge of galactic structure, of stellar distribution and of stellar dynamics ; Prof. Axel Hugo Teodor Theorell, of the Nobel Medical Institute, Stockholm, Sweden, distinguished for his work in the field of enzyme chemistry, particularly in relation to oxidation in animal tissues.

Overseas Geological Surveys : Dr. Frank Dixey, C.M.G., O.B.E., F.R.S.

Dr. Frank Dixey will retire on June 30 from the post of director of Overseas Geological Surveys. Dr. Dixey graduated in the University of Wales in 1914. After service on the Western Front from 1915 to 1918 he was appointed government geologist in Sierra Leone. He worked in Africa for nearly thirty years, and was successively director of the Geological Survey of Nyasaland (1921–39) ; director of Water Development, Northern Rhodesia (1939–44) ; and director of the Geological Survey of Nigeria (1944–47). In addition, at various times in the years 1938–44, he carried out advisory work on water development and on geological survey matters for the Governments of the Sudan, Eritrea, Kenya and Tanganyika. In 1947 the Directorate of Colonial Geological Surveys was inaugurated as a central organization in London to link and provide specialist services for the surveys overseas, and Dr. Dixey became its first director. There were then eleven Colonial territories with Geological Survey Departments. In the next ten years surveys of thirteen other territories were organized ; the number of senior staff overseas was increased from 50 to 212 ; Photogeological and Geophysical Sections were set up in London ; the Mineral Resources Division was formed by transfer from the Imperial Institute, and its activities were extended ; and among many other developments, arrangements were made for extensive co-operation with universities and other institutions in the United Kingdom. The establishment of this thriving organization is the climax of an official career during which Dr. Dixey has been the author of more than 130 publications, relating mainly to Africa. Their range includes mineral resources and water supply, Karroo and Mesozoic stratigraphy, the rift system, many aspects of geomorphology, and petrological topics, including work in collaboration with Dr. W. Campbell Smith and Mr. C. B. Bisset which afforded the first recognition of carbonatites in Africa. Dr. Dixey was awarded the Draper Medal of the Geological Society of South Africa in 1945, and the Murchison Medal of the Geological Society of London in 1953. Since 1948 he has been president of the Association of African Geological Surveys.

Dr. S. H. Shaw, O.B.E.

Dr. S. H. Shaw has been appointed to succeed Dr. Frank Dixey as director of Overseas Geological Surveys. Dr. Shaw, who is fifty-five, graduated in 1926 at the Royal School of Mines with first-class honours in mining and mining geology. From 1926 to 1928 he worked with the late Dr. A. Broughton-Edge on electrical prospecting in what is now the copper-belt in Northern Rhodesia, and from 1928 to 1930 in Australia as a member of the Imperial Geophysical Experimental Survey. He then returned to the Royal School of Mines as a demonstrator in the Experimental Department. In 1932 he joined the staff of the Geological Department of the University of Birmingham, where he continued his work on the development and application of various methods of geophysical prospecting, including resistivity measurements in boreholes. At the invitation of the Government of Southern Rhodesia, he visited that country in 1933 to make tests of resistivity methods for locating underground water supplies, with results which led to the adoption of these methods as standard procedure. In 1937 Dr. Shaw was appointed as government geologist in Palestine, where he served until the termination of the mandate in 1948. In 1949 he joined the Directorate of Colonial Geological Surveys, and was charged with the task of initiating and developing the Photogeological and Geophysical Sections. He was promoted to deputy director in 1950. Dr. Shaw's publications include part-authorship of the official report of the Imperial Geophysical Experimental Survey, and a series of papers on resistivity work and on the estimation of free quartz in rocks by micrometric methods.

Geology at Leicester : Prof. P. C. Sylvester-Bradley

Peter Colley Sylvester-Bradley, appointed to the recently created chair of geology in the University of Leicester, was educated at Haileybury and the University of Reading. After a short period in charge of the Department of Geology at the Seale-Hayne Agricultural College (1937–39) he served in combined operations, and later as administrative officer in a branch of the Admiralty Operations Division in the Mediterranean. His appointment to the staff of the Geology Department of the University of Sheffield followed in 1945, and there he now holds the post of senior lecturer in geology.

Bradley's comprehensive teaching experience also includes an appointment as visiting Rose Morgan professor in the University of Kansas during 1955–56. His researches in palæontology have dealt authoritatively with fossil Ostracoda, for he is part author and general co-ordinator of the volume dealing with these fossils in the "Treatise on Invertebrate Palæontology". Other fields of palæontological research are concerned with the fossil oysters of the Jurassic of north-west Europe, and with the ammonites of the Lias of the Yorkshire coast. His published work also bears witness to a deep interest in fundamental and philosophical aspects of palæontology, such as those concerned with the study of communities, with speciation, and with the taxonomic problems which arise therefrom. This varied and successful research activity has been recognized by the Geological

Society of London in the awards of the Wollaston Fund in 1953, and the Edmund Johnston Garwood Fund in 1957.

Bradley's active participation as a member of council of a number of geological societies and associations, together with a period (1953–57) as editor of the Yorkshire Geological Society, is a measure of the importance of his contribution to, and interest in, the welfare of his science. His enthusiasm and energy are combined with a strong and pleasant personality and his friends and colleagues look forward with anticipation to a most successful tenure of the chair of geology at the University of Leicester.

Ministry of Supply: Mr. Lewis Boddington, C.B.E.

Mr. L. Boddington, a deputy chief scientific officer and director of Royal Naval Aircraft Research and Development at the Ministry of Supply, has been appointed to the rank of chief scientific officer, and will become the director-general of Aircraft Research and Development (R.A.F.); he succeeds Air Vice-Marshal P. S. Blockey, whose tour of duty with the Ministry of Supply expires in July. Mr. Boddington has been associated with research and development on naval aircraft and aircraft-carrier equipment during the greater part of his career. He joined the Royal Aircraft Establishment in 1936 and became superintendent of the Design Department in 1944. From 1946 until 1951 he was superintendent of the Naval Aircraft Department; he was appointed to Ministry of Supply headquarters in 1951, and later became the director responsible for naval aircraft research and development. He has become recognized internationally as the leading authority on naval aeronautics, and his name has been associated with a number of important developments in this field. In particular, the angled deck, of which he was the joint inventor, and the mirror deck-landing sight, which was developed under his direction, have made the operation of aircraft from carriers very much easier and safer, and have been adopted by both the Royal Navy and the United States Navy. He has also been responsible for the planning and direction of the Royal Aircraft Establishment's new research facilities for naval aircraft at Bedford. In recognition of his services to the development of naval aircraft he was awarded the Bronze Medal of the Royal Aeronautical Society in 1953.

Science Correspondent of the B.B.C.: Mr. C. L. Boltz

The British Broadcasting Corporation has created a new post at Broadcasting House, that of science correspondent in the News Division. The post is comparable to that of the Division's diplomatic and industrial correspondents and will involve duties on both sound and television. Mr. C. L. Boltz has been appointed to the post. He joined the B.B.C. in 1952, as science correspondent on the European Service, and has been broadcasting to Europe ever since. Educated at Huish's School, Taunton, and at University College, Exeter, Mr. Boltz graduated in mathematics and physics, later taking a degree in psychology at Birkbeck College (University of London) with a view to research. After a period spent in research and teaching (during the War he taught radar at Hackney Technical College), he turned to science writing. Among his best-known books are "Wireless for Beginners" and "A Statue to Mr. Trattles". He has contributed to a number of scientific journals, including *Nature* and *Discovery*. He has been an active Fellow of the Physical Society for fifteen years and has served on the Colour Group's committee for two periods. Few people have had so wide an experience of science broadcasting, for during the time he has been broadcasting from Bush House he has covered a vast range of scientific topics. Among European listeners he has a great reputation and he is one of the most popular broadcasters to give talks at Bush House.

International Commission on Higher Education in Nigeria

It was announced on April 27 that the Nigerian Government has invited a Commission comprising Nigerian, American, and British members to investigate Nigeria's needs in post-secondary education over the next twenty years, and to recommend to the Nigerian Government what steps should be taken to meet these needs. The cost of this operation is to be met by a grant from the Carnegie Corporation of New York. Sir Eric Ashby, Master of Clare College, Cambridge, has accepted an invitation to be chairman of the Commission. The names of other members of the Commission will be announced when they have all accepted invitations. It is proposed that the full Commission should meet in Nigeria in January and again in August 1960, and should produce a preliminary report for the Nigerian Government by October 1960, when Nigeria attains full independence.

Intelligence Unit for Natural History

The formation last year of the Council for Nature (*Nature*, **181**, 867; 1958) has given cohesion to the natural history movement in Great Britain, but there is a fundamental need for a central information service on matters concerned with natural history and nature conservation. At present there is no authoritative source of up-to-date information on these subjects available to naturalists. The B.B.C. has agreed to make an annual grant of £5,000 for three years to enable the Council for Nature to establish an Intelligence Unit, the first task of which will be the collection of information on what work is at present being undertaken by individual naturalists and by societies and various other bodies. By the end of the year it should be possible for the Council to provide information and advice, and to foster co-operation schemes of work and intimate what is required in the investigations of neglected fields of work. In particular it is hoped that help and encouragement can be given to amateur cinematographers wishing to make nature films. These are very important in fostering an interest in wild life in a population which is becoming increasingly urban. The Council for Nature (41 Queen's Gate, London, S.W.7) is grateful to the B.B.C. for its support, which is unconditional and places no restraint on the general services to all.

Space Research in Britain

In replying to a question in the House of Commons on April 20, the Minister of Supply, Mr. A. Jones, said that the United Kingdom missile programme could, with some adaptation, give an initial launcher in aid of a space research programme, but of itself could provide neither the satellites nor the instruments needed to attack the scientific problems of space research. The Government was at present considering the question of a British space research project using Earth satellites in the light of advice from the

Advisory Council on Scientific Policy. The Government had in mind the scope such a project would provide for co-operation with Commonwealth countries, but such discussions could most profitably proceed when the scale and nature of any British effort had been decided. Mr. Jones agreed that the danger of losing our youngest and ablest scientists to the United States in the absence of occasional opportunities for such research, even if it involved using equipment originally designed for a specific military purpose, was an important consideration. Mr. Jones promised that a statement would be made quite soon.

Commercial Manufacture of Nuclear Fuel Elements

In reply to a question regarding the circumstances in which a private company was permitted to manufacture nuclear fuel elements, and the security reasons for the refusal of the Parliamentary Secretary to the Ministry of Power to reveal, on April 21, which organization other than the Atomic Energy Authority was preparing to make such elements, the Prime Minister stated that the Parliamentary Secretary was unwilling to go into greater detail until he had been able to refer to the defence authorities as to whether any question of security arose. Mr. Macmillan now saw no objection to stating that it was the intention that Rolls-Royce, Ltd., should manufacture fuel elements for nuclear submarine machinery. The material would be supplied by and would remain the property of the Admiralty. At present all nuclear fuel was manufactured by the Authority, but it was likely that in future elements would be manufactured in some of the processes of industry. The Nuclear Installations (Licensing and Insurance) Bill at present under consideration in Committee ought to provide for this, and all such material would either be the property of the Authority or manufactured only under licence and control, for which the Bill set up a proper system. Except for a certain amount of processing, Mr. Macmillan thought that for many years all nuclear fuel would be supplied either by the Atomic Energy Authority or, for defence purposes, by the Defence Departments.

The Royal College of Surgeons of England

The recent intense activity in the Royal College of Surgeons, which has aroused considerable interest among both the professional and lay public, is not in fact a recent development. Before the Second World War the scientific work undertaken by the College had been extended by adding a Department of Physiology to the old-established Departments of Anatomy and Pathology in Lincoln's Inn Fields, London, and by establishing a centre for experimental surgical research, the Buckston-Browne Farm, at a site adjacent to Darwin's old home at Downe. But since the War, the programme of research and education has gained fresh impetus from the need for reconstruction after the grievous damage which the College suffered in 1941, and from the needs of postgraduates seeking higher qualifications in surgery, dental surgery and anæsthetics. When planning the rebuilding of the College, the Council therefore resolved that laboratories should take the place of some of the destroyed museums, and that Departments of Pharmacology and Biochemistry should be established to provide a complete syllabus of postgraduate education in the basic medical sciences which would be available not only to young surgeons but also to all postgraduates studying for any of the higher diplomas for which these subjects are required. Recognizing that teachers must be provided with accommodation and equipment for research if a high academic standard is to be maintained, the College included in its building programme a very considerable expansion of the floor area for laboratories as well as a corresponding extension of the Library. These plans were designed to discharge what the Council regarded as its plain duty to postgraduates, and to meet its ancient obligation to promote the science as well as the art of surgery.

In making these decisions the Council had to face the problem of finding the money to pay for new buildings and to maintain the new research departments. Fees from students and the welcome contribution from the University of London through the British Postgraduate Medical Federation provided only a small fraction of the sums required, which now stand at £350,000 to complete the buildings and an annual £150,000 for the salaries of teachers, research workers and technicians and for laboratory maintenance. The College exerts a far-reaching influence upon the National Health Service, but is not a hospital and therefore is not eligible for a direct grant from the Government. The Fellows have contributed handsomely to College funds, thus showing their confidence in the policy of the Council; but in order to raise these large sums of money an appeal to the public for funds has recently been launched. Already most generous support has been forthcoming from the friends of the College in industry, commerce and in the world of finance, whose example should be followed by many others who have the understanding and the vision to see that by supporting surgical research and education they are promoting the best interests of themselves, their families and their dependants.

Italian Nuclear Research Centre at Ispra

The President of Italy, Signor Gronchi, formally opened the Italian Nuclear Research Centre at Ispra on April 13 before a distinguished gathering of about a thousand people. Ispra is about a mile from the extreme south of Lake Maggiore and about 35 miles from Milan, with which it is connected by *autostrada*. The centre is set in a beautiful district and occupies 340 acres of part grassland and part woods. Ultimately it should have a working population of around a thousand. Work began on the site in the late summer of 1957 and later in the year an organization headed by Prof. Carlo Salvetti was set up in Milan to prepare for the move to Ispra. About three weeks before the official opening of the centre, *Ispra*-1, a 5-MW. heavy water-moderated research reactor, fueled by 20 per cent enriched uranium with a fast neutron flux of $1{\cdot}1 \times 10^{14}$ $n/cm.^2$ sec. and a thermal neutron flux of 8×10^{13} $n/cm.^2$ sec., went critical. This reactor is a modification of the *CP*-5 reactor at the Argonne National Laboratory which operates at 1 MW. The moderator and fuel for the reactor were imported from the United States, as were some of the most important reactor components, so as to speed up the construction of the reactor. At the opening ceremony the United States Atomic Energy Commissioner, Mr. Floberg, made a speech in Italian and handed a cheque for 350,000 dollars to President Gronchi as the American contribution to the cost of the reactor.

Ispra-1 is enclosed in a gas-tight metal cylinder, 79 ft. high, which is kept at a negative pressure as a safety measure. Several laboratories are grouped

around the reactor, and a metal chimney stack, more than 200 ft. high, towers over the metal shell. The reactor is intended primarily for research purposes and its scope of activities is very similar to that of the *Pluto*-type reactors, to which it bears some resemblance. The Ispra centre will provide a valuable addition to the Italian nuclear scene, which includes the centre for fundamental research at Frascati and the new centre for research studies to be built near Rome. Italy, in common with most countries in western Europe, is increasing its consumption of power at the rate of about 7 per cent a year, and with the hydroelectric power potential in the north fully exploited, Italy has begun a nuclear power programme that should give a capacity of 500 MW. by 1964. At present the 200-MW. reactor being built by the Nuclear Power Plant Company for Agip Nucleare is the most advanced of the reactors under construction.

Braille Translation by Computer

IBM MATHEMATICIANS, working with the American Printing House for the Blind, have developed a process for translating printed text into Braille by computer. The computer used is an *IBM* 704 which can convert a 300-page book into Braille in an hour—a job that would take skilled translators more than six days. This new technique will make available many school and technical books now rarely produced in Braille, thus enlarging the possibilities for careers for the blind. To speed this translation, printed texts will be recorded on magnetic tape and distributed to IBM computer installations, where they will be translated and the cost borne by IBM United Kingdom, Ltd.

Writing Braille requires knowledge of many complicated rules, the symbols often changing their meaning in a different context. Braille consists of 63 combinations of six raised dots which represent not only the letters of the alphabet, numerals and punctuation marks, but also 183 special contractions and abbreviations, as in the case of shorthand. Texts to be translated by the computer are first transcribed on to punched cards. The cards are then fed directly into the computer, which has had previously stored in its memory a programme for conversion of English into Braille. The translated text emerges from the computer in coded symbols on punched cards, and these, in turn, are fed to the printer unit of the *IBM* 704, which reproduces Braille symbols above the English text. After editing, the corrected punched cards are fed into an embossing machine which produces metal plates ready for use on a rotary press.

Denudation and Burial of Archæological Structures

THE British Association (Section *H*) has formed a special committee to "investigate by experiment the denudation and burial of archæological structures". The aim of the committee, the members of which are Dr. G. W. Dimbleby (chairman), Dr. P. Jewell (secretary), Prof. R. J. C. Atkinson, Dr. I. W. Cornwall and Dr. B. Proudfoot, is to obtain precise measurements of the rates at which soil moves and accumulates, how far buried objects may move in the soil, and the way in which buried objects disintegrate and decay. Building a simple ditch and bank with incorporated markers, and following the rate of silting of the ditch, and of denudation and spreading of the bank, formation of turf and compaction of soil, over the following years would help to answer some of the questions. Comparative results will be obtained from sites established in different parts of Britain. The observations should not only aid in the interpretation of archæological excavations but may throw more light on the changes that past land-use has produced. Buried materials will include wood, charcoal, bone and metal, treated in different ways, and their examination in the future may enable more information to be obtained from the accumulating finds from archæological sites. The committee will be very glad to hear from anyone interested in the project, particularly those whose specialist knowledge might help in laying out the structures, and who in turn might derive information of interest from the experiments. The secretary of the committee is Dr. P. A. Jewell, Royal Veterinary College, London, N.W.1.

A Century of Biological Research in Illinois

THE Illinois Natural History Survey Bulletin (27 ; 1958), entitled "A Century of Biological Research" (Pp. vi+85–234. Urbana : Illinois Natural History Survey, 1958), deals with the development of biological research in a mainly agricultural community, in which the practical problems affecting land-use and agriculture have largely controlled the outlook of the investigators as well as the policy controlling development. This is reflected in the five main lines of progress summarized, namely, economic entomology, faunistic surveys, applied botany and plant pathology, aquatic biology, and wild-life conservation. The work has, however, included notable contributions of a fundamental nature, and the brief outlines of these included in this Bulletin are of considerable interest. The rapid changes in Illinois due to the transformation of woodland and swamp to farmland, and to the utilization of the now 'vanishing prairies', have all greatly affected the plant and animal populations. These have been followed in studies and records which can scarcely be paralleled anywhere over so long a period. As one example, map records are given of the density of populations of a wheat predator, the chinch bug (*Blissus leucopteris*), available since 1840. Other examples trace the gradual disappearance of prairie animals, such as the prairie chicken, as arable land has replaced grassland, while the recorded fluctuations of the bob-white quail or of ducks and geese or of introduced pheasants, in areas of diverse ecological character, have abundantly justified the bird-census techniques which were adopted at an early date. Very well known to freshwater biologists are the massive pioneer papers on the plankton, bottom-fauna and fishes of the Illinois River. Not only do they record some of the earliest quantitative work in these fields but also the 'indicator' species present and succeeding one another, as drainage and pollution modified the character of the river. This Bulletin is therefore a valuable guide to records which trace the growth of modern aspects of wild-life conservation from earlier efforts concerned simply with crop protection. It is, incidentally, also a memorial to the genius and foresight of A. S. Forbes, who for so long guided the destinies of the organization.

National Science Foundation Fellowships

THE National Science Foundation has awarded 1,100 graduate fellowships in the natural sciences and allied fields for the academic year 1959–1960. In addition, the Foundation has announced the names of 160 winners of regular postdoctoral fellowships. Of

the graduate awards, 216 were made in the life sciences, 866 in the physical sciences, including a number in interdisciplinary fields, and 18 awards were made in certain areas of the social sciences. Of the postdoctoral awards, 55 were made in the life sciences, and 104 in the physical sciences, including a number in interdisciplinary fields, and in the field of econometrics.

The Genetic Concept of the Origin of Cancer

THE theory that malignant transformation in cells may be considered to be a genetic event was suggested in 1908 by J. A. Murray of the Imperial Cancer Research Fund (London), but experimental evidence had to wait twenty-years until inbred mice were available. In this respect the credit is due to the pioneering work of Dr. L. C. Strong (Buffalo), who was the organizer and chairman of a conference on "The Genetic Concept for the Origin of Cancer", supported by the New York Academy of Science and the National Institutes of Health (Bethesda). The papers presented by 29 contributors at the Conference, which was held in New York, October 1957, have now been published (*Ann. N.Y. Acad. Sci.*, **71**; 801–1241; 1958). They are representative of the various aspects of cancer research of the past three decades. The diverse subjects discussed include: the role of genetic and environmental influence in the causation of experimental cancer; the effect of selection on transplanted tumours; the occurrence of tumours in plant and animal interspecific hybrids; the modifying effects of genes on melanotic tumours in the fruit fly *Drosophila*; the nature of carcinogen-induced mutations in *Neurospora*.

J. Schultz (Philadelphia) attempted to show how our knowledge of genetical changes in somatic cells can be related to malignant change. D. B. Amos (Buffalo), on the other hand, gave examples to illustrate how the antigenic patterns of tumours can be used as a tool to study somatic genetics. The relationship between chromosome changes in tissue culture of mammalian cells and those observed in tumour cells was brought to the fore by A. Levan (Lund) and J. J. Biesele (New York); the possible relevance of certain types of phage mutations to malignant transformation of cells was discussed by S. E. Luria (Urbana). Papers by P. A. Gorer (London) and C. P. Oliver (Austin) deal with the genetics of human cancer, both agreeing that genetically determined predisposition to a particular type of cancer is present in certain families.

Royal Institute of Chemistry: Officers

MR. E. LE Q. HERBERT, managing director of Shell Refining Co., Ltd., was recently elected president of the Royal Institute of Chemistry for 1959–61. He took over this office from Dr. D. W. Kent-Jones (president 1955–57), who had been acting president since the death, on December 19, 1958, of Prof. W. Wardlaw (elected president for 1957–59). Dr. C. W. Herd, Prof. Charles Kemball and Mr. Clifford Paine were elected vice-presidents for 1959–61. Prof. Harold Burton was re-elected honorary treasurer for the ensuing year.

Iron and Steel Institute: Changes on Council

The following new members were recently elected to the Council of the Iron and Steel Institute: *President*, Mr. W. Barr; *Honorary Treasurer*, Sir Julian Pode; *Vice-Presidents*, Mr. B. Chetwynd Talbot (chairman and managing director, South Durham Steel and Iron Co., Ltd.), Mr. C. H. T. Williams (managing director, Park Gate Iron and Steel Co., Ltd.); *Ordinary Members of Council*, Major W. R. Brown (chairman, Ashmore, Benson, Pease and Co., Ltd.), Mr. T. R. Craig (director, Colvilles, Ltd.); *Additional Honorary Members of Council*, Dr. N. P. Allen (director, Metallurgy Division, National Physical Laboratory), Mr. A. Jackson (technical adviser on steelmaking, United Steel Companies, Ltd.).

Announcements

DR. D. A. LONG, recently on the staff of the Medical Research Council at the National Institute for Medical Research and during 1957–58 visiting professor in microbiology in the School of Medicine at the University of Pittsburg, has been appointed chief medical adviser and head of the Medical Research Department of the Wellcome Foundation, Ltd.

THE Physical Society is holding a conference on "Co-operative Phenomena and Phase Transitions" at King's College, Newcastle upon Tyne, during July 6–7. Further information can be obtained from the Secretary, Physical Society, 1 Lowther Gardens, London, S.W.7.

UNESCO is holding an arid zone symposium at the Instituto Nacional de Investigaciones Agronomicas, Madrid, during September 24–30. Summaries of proposed papers must reach the Department of Natural Sciences, Unesco, Place Fontenoy, Paris VII, by June 1. Further information can be obtained from the above address.

A CONVENTION on "Television Engineering in Science, Industry and Broadcasting", organized by the British Institution of Radio Engineers, will be held in the University of Cambridge during July 1–5. Delegates may reside in the colleges of the University. Further details can be obtained from the Secretary, British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1.

AT the summer conference of the Society for Applied Bacteriology, to be held in London during July 7–9, a symposium will be held on "Lactobacilli". Those interested in attending, or contributing to, this symposium can obtain further details from the honorary secretary, G. Sykes, Boots Pure Drug Co., Ltd., Microbiology Division, Standards Department, Nottingham.

THE fourteenth Annual Electronics Exhibition and Convention of the Northern Division of the Institution of Electronics will be held at the Manchester College of Science and Technology during July 9–15. It will include extensive displays of electronic equipment of interest in all branches of science and industry. Details can be obtained from the Honorary Exhibition Organizer, Mr. W. Birtwistle, 78 Shaw Road, Rochdale, Lancs.

A MATHEMATICAL colloquium is to be held under the auspices of the Edinburgh Mathematical Society in University Hall, St. Andrews, during July 8–18. The principal speakers will be: Prof. H. S. M. Coxeter (subject to be announced), Prof. V. C. A. Ferraro (magnetohydrodynamics), Prof. C. Lanczos (linear operators and function spaces), Dr. A. P. Robertson (functional analysis), and Dr. R. Schlapp (history of mathematics). Further particulars and forms of application can be obtained from Mr. J. R. Gray, St. Salvator's College, St. Andrews.

EDUCATION FOR GOVERNMENT

A DEBATE on the motion "That the education of our future rulers should be primarily in the sciences rather than the humanities" was held in the Beveridge Hall, Senate House, University of London, on March 18. Sir Cyril Hinshelwood was in the chair; the motion was proposed by Sir Alexander Fleck, seconded by Prof. A. R. Ubbelohde, and opposed by Prof. B. Farrington, seconded by Prof. W. Beare. The debate was sponsored jointly by the London Section of the Royal Institute of Chemistry, the London branch of the Classical Association and the Haldane Society.

Sir Cyril remarked, in opening the proceedings, that he supposed he owed his position on the fence on this occasion to the fact that he happened to be president of the Classical Association as well as president of the Royal Society. He asked that there should be a straight fight on the arts versus science issue implied in the motion, but in this he must have been rather disappointed. Scarcely a speaker could be found to defend the motion as worded, and it was necessary even for Sir Alexander Fleck to assure his audience that whatever he might say, he was, in fact, moving the motion. His reluctance to do so stemmed not only from his slender acquaintance with the classics—failures in Latin having on two occasions "almost wrecked an otherwise promising career"—but from his dislike of the term "our future rulers". Any suggestion of a Platonic *élite*, selected by some process of intellectual eugenics, was repugnant to him. But there was an urgent need to orient the education of the people as a whole so that the statesmen and leaders they produced would be capable of handling scientific ideas. He contrasted, not too seriously, the legendary pedantry and otherworldliness of the classical scholar, with the severely practical, positive approach which a scientific training could bring to the consideration of human affairs. He believed, with Lord Cherwell, that it was more important to know something of the properties of chlorine than of the improprieties of Clodius. The continued growth of science and of informed opinion about science was vital to our country and to all peoples.

Prof. Benjamin Farrington, in a persuasive speech, opposed the motion on the grounds that it appeared to imply that there should be a compulsory tilt in the whole educational system so as to give primary emphasis to science. He had no quarrel with science —we should spend even more of our resources upon it in the future than we do at present—but it was essential that science remained the servant, not the master. The transformation of human life by science in the past three hundred years had been remarkable, but it had produced problems to which science by itself had no answers. The problems raised by automation, for example, or the whole question of man's survival, were beyond purely scientific answers. The humanist could survey the whole development of the marvellous being we called Man. This did not imply a backward-looking philosophy: it was the only hopeful way of looking to the future. Man alone had the power of creating his own inner world, the world of ideas, and he had drastically changed life on earth by his rational acts. The human intellect was the greatest force in the universe, since it alone could produce change. Science was one of man's achievements, but it was not the only one of significance. Scientists often seemed excitable, unstable, and at the mercy of every new idea. They were apt to be misled into new superstitions and to confuse their abstractions and concepts with reality. Hence one heard of discussions about the psychology of the man-made machine, when no machine could possess consciousness. The study of conditioned reflexes in organisms was important, but they did not supersede the rational acquisition of knowledge. The humanist was concerned with the conscience of man, in which is enshrined all the long history of man's endeavour; he must remain master.

Prof. A. R. Ubbelohde was prevented from being present by illness and his speech in support of the motion was read for him. The role of science had changed completely since the time when Dr. Johnson had ruled that "speculations upon matter are voluntary, and at leisure". It was necessary to continue the age-old process of adapting the content of education to the requirements of a changing society and admit science to the priority. A knowledge of science should be as fundamental an element of education in the future as were reading, writing and arithmetic to-day. Our future leaders would be at a disadvantage if they had not had scientific training; to understand and control the power of science would be one of their prime responsibilities. We could not risk that the potentialities of applied science should be at the mercy of "humanistic Druids" whose sympathies lay wholly outside the sciences. Scientific knowledge now formed one of the major empires of the human intellect; its disciplines threw new light upon old problems of human existence. The scientist soon learnt a humility in the face of objective facts which would stand many a politician in good stead. He was also accustomed to co-operating with his fellows across national boundaries in an international community of endeavour. There were dangers in too narrow an approach in scientific studies, as there were in all academic studies, but these were recognized and could be avoided. It would be a far greater danger to leave our future rulers in ignorance of science.

Prof. W. Beare, in seconding the opposition, said that the fact that they were debating this motion showed that there was a widespread uneasiness about the objects of education. Since there was no clear answer it was important to preserve freedom of choice. The idea that the education of the whole community should be compulsorily slanted was dangerous. It were better that a man should be a first-rate historian than a second-rate chemist. Our citizens and voters would be better guided by a knowledge of history than of quantitative science, but the study of any subject could not, of itself, make a good citizen or ruler—it was the knock-about of everyday life which was the true education. He did not grudge the scientists their palatial new premises, even though a new hat-rack might prove to be more than could be managed for the arts faculty. But a knowledge of thermodynamics would tell you nothing about hell-fire; our rulers should come from the humanists who had studied the

imperfections and sins of man, as well as his potentialities.

When the discussion was thrown open it soon became clear that the motion had found few friends. The first two speakers were classicists; Dr. R. E. Witt spoke from experience as a headmaster of a grammar school and said that the study of Greek seemed to produce a greater humility, a greater readiness to look on the other side of a problem, than the study of scientific subjects. Mrs. M. Lockwood suggested that our leaders should have a humanistic philosophy within which their problems could be judged. Scientific progress seemed frighteningly aimless and uncontrolled; there was a suspicion that the real spur to our scientific effort was simply fear of the U.S.S.R. Prof. Timonen, of the University of Helsinki, pointed out that some of the greatest scientists had had a sound classical education and that this had probably contributed to their clarity of thought and expression.

There followed contributions by four chemists, but only one favoured the motion. Dr. A. C. C. Newman urged the importance of inculcating moral values during the education of the citizen. Political leaders had to deal with issues which were primarily moral and human; so long as they were well advised on scientific questions that was enough. Dr. H. J. Barber suggested that the study of the history of science could provide a valuable synthesis of the humanities and the sciences; it should take its place in curricula along with political history. Mr. R. A. Frazer disliked the suggestion that the sciences should predominate in education—a balance should be struck with emphasis primarily on the humanities. Mr. F. F. Ross agreed that the learning of Latin was a valuable discipline in primary education, but it should give way to science later. An understanding of man's scientific progress was basic to the study of history.

Prof. Farrington, in replying for the opposition, deplored the fact that the necessary expansion of the science faculties of British universities had been accompanied by drastic reductions in the facilities for studying ancient and modern languages and cultures. This was bringing about an undesirable change in the character of the universities themselves.

Sir Alexander Fleck, summing up for the motion, strenuously denied that the motives for the expansion of science were political. Man might not live by bread alone, but bread was still a necessity, and it was up to science to provide it. Only if our leaders understood science could it be used to improve life on earth.

Sir Cyril Hinshelwood then put the motion to the meeting and it was heavily defeated. A vote of thanks to the chairman and the speakers, proposed by Dr. S. A. Miller, was carried with acclamation.

N. Lindop

DETERGENTS, TEXTILES AND DYES

A CONFERENCE on "Detergents, Textiles and Colour", organized by the Textile Institute in collaboration with the Branded Textiles Group, was held on February 11 in the Lesser Free Trade Hall, Manchester. Mr. Roland Thomas (director, C.P.A., Ltd., Branded Textiles Group), opening the meeting, said that the products produced by the Group were guaranteed and that members of the Group were interested in maintaining high quality in a very large range of textile goods. Serious consideration had been given for two and a half years to problems arising from the new detergents; on the subject of deterioration of textiles, the detergent manufacturers' attitude to complaints had been that: (*a*) they were not true, (*b*) if true, it did not matter, (*c*) if it did matter, nothing could be done about it, and (*d*) if anything could be done, it would be too expensive. The problem was serious, the housewife was lost in the complexities of advertisements and it was the business of industry to find a solution.

In the morning three papers were read and a number of excellent demonstrations shown to illustrate loss of tint by lack of fastness of dyes to detergent mixtures, by contamination by fluorescent bleaches and by chemical bleaching.

Mr. C. F. Ward (on behalf of the Branded Textiles Group) referred to the great increase in recent years in the number and variety of textiles and also of detergents and substances added to the synthetic soaps. It was fortunate, he said, that in this change emphasis has been placed by the textile manufacturer more and more upon quality. He listed detergent requirements and mentioned the need for instructions understandable by the non-technical housewife. Detergent compositions were discussed, particularly the so-called optical bleaches—the colourless blue-fluorescing substances used to give the "whiter-than-white" look. The danger of transfer of these substances from one article to another in the wash was pointed out and, in particular, the most objectionable effect upon the tint of textiles originally dyed to pastel shades such as peach and nil which, after contamination by the fluorescent optical bleach, appear pink and dirty blue.

Complaints of faults caused by the chemical bleach in the detergent powder, such as 10 per cent sodium perborate, were described; in particular of a royal blue dye on wool which develops yellow patches and spots at temperatures as low as 110° F. Cellulosic materials develop pin-holes either through the action of particles of the bleach which have not been completely dissolved, or through local traces of metal catalysts causing violent action by the dissolved persalt. Fading of dyes in sunshine while drying on the line may be attributed to incomplete rinsing of alkali. Some optical bleaches are themselves not fast to light and discolour in sunlight. The quite common practice of the housewife adding bleach containing chlorine to a detergent when washing whites leads to further troubles; Mr. Ward said that he understood that organic chloro-compounds are already being added to domestic washing powders in the United States and are being considered for use in Great Britain. He viewed this with the greatest concern, since it would lead to increase of complaints of loss of colour, fading, local bleaching, and loss of wear.

Mr. Ward concluded by saying that the housewife is puzzled by the number of products and the various claims made for them; whereas he had no objection to optical bleaches for those who want them for whites, he did complain that colours of textiles are

Table 1

Soap	(per cent)	Non-soap	(per cent)
Soap	40–65	Sodium alkylanyl sulphonates	20–22
Sodium carbonate	5–20	Other wetting or frothing agents	0–5
Sodium silicate	3–5	Sodium polyphosphates	30–40
Sodium phosphate	0–10	Sodium perborate	10
Sodium perborate	0–10	Sodium silicate	5
		Sodium sulphate	20

spoilt by them, and argued that there should be available a detergent containing no bleach and no optical brightener.

Mr. F. P. Thompson (Unilever Ltd.) then spoke on the problem from the point of view of the manufacturer of detergents. He gave the typical compositions of washing powders of the soap (classical carboxylate) and non-soap (synthetic detergents) types, shown in Table 1. Both contain 0–1 per cent of sodium carboxymethyl cellulose and 0·02–0·08 per cent of optical bleach.

Mr. Thompson claimed that perborates have negligible effects upon most dyes and that oxygenated bleaches do not cause loss of strength of textiles. Perborates give better removal of some soils than manual scrubbing. With reference to the bright blue dye which turns green or yellow, he said that no change in shade is produced by carboxylate soap; with perborate it changes shade gradually, the effect being greater in soaps than in synthetic detergents. The change in colour increases with temperature and with concentration of suds. Loss of strength of textiles is least for the carboxylate soap; but with perborate it is much the same for all types of soaps and detergents.

Mr. Thompson spoke of many reports that no discoloration is caused by repeated washing with optical bleaches. He spoke of the difference between the skills and desires of the housewife and the technical expert, and also of the education of domestic users which is carried on by the makers of detergents.

Mr. G. S. J. White (Imperial Chemical Industries Ltd.) gave a brief account of the outstanding advances in the discovery of new dyes, pointing out that major new discoveries occurred at intervals of about thirty years. The requirements of a dye were listed as, first, ease of application; secondly, colour fastness and, to-day, fastness to detergents; and thirdly, colour gamut. Most attention has been given and most success achieved in making products easier to apply. On the other hand, those dyes most easily applied are least fast, and fastness requires more expensive dyeing processes. A striking demonstration was shown of a blue dye which, when made soluble by sulphonation, is applied easily but shows serious loss of colour on washing. When the dye is chemically bonded by the more expensive process of attachment by the cyanuric chloride reaction, only slight loss of colour occurs. When made soluble by a quaternary nitrogen atom and fixed upon the fabric by dequaternizing, it is fast to detergent; but this is the most difficult and expensive method of dyeing.

Mr. White recalled the pre-war German label guaranteeing fastness of dyed textiles to detergents and light, and mentioned the present 'Felisol' label controlled by an international committee which tests dyes and dyeings. He regarded the flow of information from the dye maker to the dye user as very good, but pointed out the paucity of the return of information and complaints from users. He estimated the annual world expenditure on research by dye makers as £15 million, of which about £4 million was spent on the salaries of chemists. He concluded by claiming that the problem of the ultimate consumer who still encounters textile goods of poor washing fastness can broadly find alleviation, if not entire resolution, within the textile industry itself, using the whole wide range of products of the dye manufacturers.

Dr. A. S. C. Lawrence (Sheffield), opening the discussion, said that it was clear that the main reason for the meeting was the composition of detergent mixtures; that the meeting was held to discuss whether the additional obligation laid upon dyestuff makers and textile manufacturers by the composition of detergent mixtures is, first, more than they can be reasonably expected to meet to protect the interests of their users and their own good name; and, secondly, whether this additional obligation is necessary for improving detergents or if it is a passing and unnecessary phase which will die out in a few years.

There were three stages in the development of detergents: first, their appearance on the market and the addition of builders to improve their action upon cotton; they were a boon, especially in hard water. The second step was that of adding a bleach, and the third was the addition of a white substance with blue fluorescence—the optical bleach to give the "whiter-than-white" look. This is a dye and a very bad one because it is not fast to detergents; it is now broadcast throughout the washtub. It might be possible for the dyestuff makers to produce an optical bleach that is fast. Alternatively, following Mr. Ward's suggestion of different products for different duties, Dr. Lawrence suggested three types of detergent; one, consisting of detergent and builder only for use in washing up, for paint, etc., and for all coloured and dark textiles; the second would contain also the bleach for occasional use on whites; and the third would have detergent, bleach and the fluorescent optical bleach for those who wanted it. The makers should sell each in a distinctively coloured package—say, red, blue or white—upon which their name and instructions should be printed. Members of the public have been so confused by advertisement campaigns that they either fail to read the maker's directions or mistakenly suppose that all brands are equally good.

Dr. Lawrence said that all the intelligent young women whom he had questioned said that they used only carboxylate soap for their clothes and synthetic detergents (often those containing the bleaches) only for domestic housework—a duty for which their formulation makes them unsuitable and uneconomical.

The basic reason for holding the meeting was the policy of marketing detergents which are compounded as Jacks-of-all-trades and masters of none. There seems to be a need for fundamental research into the nature of the soil responsible for the greying of whites and of the forces responsible for its persistent adhesion. The paradox which this material presents is that it is removed by the non-detergent components and not by the soap.

In the discussion, much evidence was given of complaints of faults arising during washing being reported to the manufacturer of the textile article. Patchy changes of shade due to the optical bleaches occur on twin-sets; rhodamine pink is not fast to detergents. The maximum degree of brightness from the optical bleach can be built up in an article free of it by washing in suds, containing none, from other articles which have been loaded. Faults due

to the perborate chemical bleach include yellowing, said to be due to incomplete rinsing, and loss of colour, both generally and in spots. The latter were attributed to incomplete solution of the perborate in the hot water before the articles to be washed were put in. Two speakers said that they had seen advertisements for detergents on television in which this incorrect and dangerous procedure was shown. It was generally agreed that loss of strength is not a problem and that when it does occur, faulty rinsing is the cause. Bleaching on the line, especially during drying in sunlight, was also attributed to this cause. Serious disquiet was expressed at a report of the addition of bleaches containing chlorine to domestic detergents in the United States, and of their possible use in Britain.

A number of speakers made it clear that they considered that some detergent compositions, likely to cause damage to some textile goods of high quality, are being sold to housewives without adequate and sufficiently clear instructions. It is claimed by the manufacturers of these detergents that their inquiry and education services find none of the faults described. On the other hand, a manufacturer of baby clothes who guarantees to replace faulty goods has reported numerous complaints of change of colour, and said that a recommendation to use a selected detergent free from the objectionable additions has led to a large decrease in the number of complaints. He suggested clear classification of all detergents into two groups, one for whites and one for coloured goods. This and similar labelling proposals were received with applause by the meeting. It was stated that the dyestuff makers were unable to produce an optical bleach fast to detergents.

Dr. A. S. C. Lawrence, summing up, said that three main points had emerged from the meeting. First, that the light-fast dyes, which the dye maker can produce, require dyeing processes to make them fast to detergent compositions as now generally sold and this involves extra cost. Secondly, that the textile manufacturer receives the complaints, for the obvious reason that a woman who has purchased a relatively expensive article will complain to the shop where she bought it rather than write to the manufacturer from whom she has obtained a few pennyworth of detergent. Thirdly, that communication of highly technical matters to and from a technologically ignorant public is impossible, and the claims of success of inquiry and education services of the detergent manufacturers must be regarded with suspicion. New textile goods heavily loaded with optical bleach are already being sold, so that a ban on fluorescent brighteners in detergents would not be enough. It seems that some co-operative standard of labelling by makers of detergents, to distinguish in a simple and unequivocal manner for the ordinary housewife the basic types of composition, is the only satisfactory solution and one much overdue. Alternatively, makers of textiles will have to label their goods, specifying a safe detergent, until the makers of the present potentially harmful compositions, so widely sold, are driven to a more critical consideration of their duty to the public. A. S. C. Lawrence

FORESTRY IN THE UNITED KINGDOM

While the Society of Foresters of Great Britain, having been formed in 1925, is the youngest of the British societies concerned with forestry, its membership is the most representative of the profession as, although it has an ordinary membership open to all who are interested, it caters primarily for the university graduate and others with equivalent qualifications. Its journal, *Forestry*, is published twice yearly. During the past year, it has published about a dozen original articles ranging over a very wide field, tending to be ecological rather than technical, though some of them link the two aspects; for example, a study of the effect of rate of growth on the density of timber.

The opening article in the 1958 volume is a thoughtful study by G. B. Ryle (at the time, the Forestry Commission director for Wales) on the social problems and possible developments in upland grazing areas where forestry is the obvious alternative use to sheep farming. A strong case is made for integration of farming and forestry, both uses being taken equally into account; action should be co-ordinated by combined councils and the mistakes of the past should be avoided. There have been faults on both sides, the agriculturist seeing the problem as one of maintaining the farm with the help of subsidies, etc., even when it is uneconomical, or less economical than alternative uses, while the forester has tended to overlook the fact that both winter and summer feed must be available to a sheep farm. Ryle also adduces fairly conclusive evidence that forestry gives more on-the-spot employment than sheep farming—probably twice as much—and stresses the need for improved housing as extensions of existing communities rather than new isolated centres.

A study of the mineral content of standing pine crops on the Culbin Sands by T. W. Wright and G. M. Will shows that a maturing crop with about 50 tons of dry organic substance contains about 170 lb. nitrate, 20 lb. phosphate, 100 lb. potassium, 160 lb. calcium and 32 lb. magnesium, of which about one-third to one-quarter is in the leaves and so returned to the ground annually; the wood, which alone is ultimately removed (provided the bark is peeled on the spot), contains less than one-fifth of the total. These figures, despite their smallness, are of considerable significance in relation to the very low mineral content of the blown sand.

Two papers deal with different aspects of a field that is attracting increasing attention, namely, the relation between the physical conditions, both natural and due to manipulation, under which trees are grown, and the properties of the timber they produce. Studies of site factors influencing growth are discussed in another two papers dealing, respectively, with wind effects and the measurement of light intensity. Taxonomic studies are represented by a paper on the elms of south Cambridgeshire and one on the named variants of the Scots pine. In view of the importance of the latter tree in afforestation and its wide distribution and range of forms, this analysis of 144 terms already published is a most useful contribution: it describes no less than twenty-six geographical varieties and twenty-five habit

forms, together with many named variations in bark, foliage, cones, timber and seed.

The Royal Scottish Forestry Society was founded as the Royal Scottish Arboricultural Society in 1855 and its published transactions have developed into the current quarterly *Scottish Forestry*. While this Society draws its membership from a wider field than the Society of Foresters of Great Britain, and has a much bigger proportion of the non-professional element, its journal regularly includes original articles of considerable interest and value. Among those appearing during the year, mention may be made of a paper on the practical issue of using a knowledge of the life-history of the fungus (*Keithia*) which is liable to affect seriously the growth of *Thuja* seedlings, to raise healthy nursery stock of this tree; isolated nurseries used once only or in rotation, with due precautions to avoid sources of infection, are the solution. There is an interesting paper on the variation of susceptibility of European larch of different seed origins to frost, and another on 'group strike' by lightning, a case being reported of one hundred trees dying with only two showing actual scars, and a comparable case in a nursery. The morphological field is represented by a paper on bark variation in birch and its relation to figured wood.

The present Royal Forestry Society of England and Wales was founded in 1882 as the English Arboricultural Society, on similar lines to its Scottish counterpart. Its transactions appeared from 1884, becoming the *Quarterly Journal of Forestry* in 1907. As might be expected, a very similar range of original papers is being published, including in 1958 three on the properties of coniferous timbers as affected by treatment during growth, one on the effect of liming ploughed or unploughed upland moors, and one on the 'mechanized forest'.

Mention should not be omitted of the *Empire Forestry Review*, published quarterly by the Empire Forestry Association, which includes a proportion of original articles on British forestry among its much wider coverage; these are chosen primarily for their general interest though, of course, forestry issues are very similar all over the world. The chief items of this type in 1958 are on desirable road density in plantations and intensive methods of raising coniferous seedlings. In addition, there are the 'Men of the Trees' publishing *Trees* two or three times a year.

H. G. CHAMPION

FOOD INVESTIGATIONS

THE recently published report of the Food Investigation Board* for 1957 also covers the work of the Torry Research Station and the Humber Laboratory concerning the improved handling and processing of fish; the Low Temperature Research Station on meat, eggs and various plant foods; and the Ditton Laboratory and the Covent Garden laboratory concerned mainly with conditions of storage for fruit and vegetables.

A report of this nature provides an excellent illustration of the complexity of the problems associated with the maintenance of an all-the-year-round supply of food in an industrialized, urbanized community. In the main, the work is concerned with preserving food and this requires a study of differences in the initial state of the food, of the conditions of handling to which it may be subjected, and of methods of detecting early stages of deterioration, quite as much as a study of all aspects of the different methods of preservation, which include such varied means as the use of antibiotic ice, electronic radiation, electrostatic smoking, vacuum freeze-drying, gas storage, etc.

The Board stresses "the vital importance of the closest possible co-operation with the appropriate user industry from the outset of a research through all its stages to its final implementation". Several of the investigations concerning fish were made at the request of the White Fish Authority, the Herring Industry Board, and the National Federation of Fishmongers, and a committee of the National Farmers' Union was consulted when the research programme of the Ditton Laboratory was being planned. This is welcome collaboration and should not only ensure direction of effort towards the problems most urgently in need of solution but also speedy application of any solutions which might be found.

M. W. GRANT

* Department of Scientific and Industrial Research. Food Investigation 1957: The Report of the Food Investigation Board with the Reports of the Superintendents of the Torry Research Station, the Low Temperature Research Station, and the Ditton Laboratory. Pp. vi+81. (London: H.M. Stationery Office, 1958.) 5s. net.

REMANENT MAGNETISM OF THE ALLARD LAKE ILMENITES

By CHARLES M. CARMICHAEL

Department of Geophysics, University College, University of Western Ontario

THE Allard Lake region of Quebec contains numerous outcrops of massive ilmenite enclosed in Grenville-type anorthosite of pre-Cambrian age. Hammond[1] has described the region, particularly the Lac Tio deposit, which is the largest of its type in the world.

Although the ore is usually referred to as ilmenite, it should be called hemoilmenite, since it consists of about 70 per cent ilmenite ($FeTiO_3$) and 25 per cent hematite (Fe_2O_3), with the remainder being largely composed of feldspar, pyroxene and pyrite. The massive ore consists of relatively large crystals averaging about 3–5 mm. in diameter. The hemoilmenite solidified originally in homogeneous crystals, and then upon cooling separated by exsolution into an ilmenite-rich phase and a hematite-rich phase. The hematite-rich phase has exsolved in the form of thin discontinuous lamellæ with their long and intermediate axes in the basal plane of the rhombohedral host-crystal. Thus the lamellæ have the general

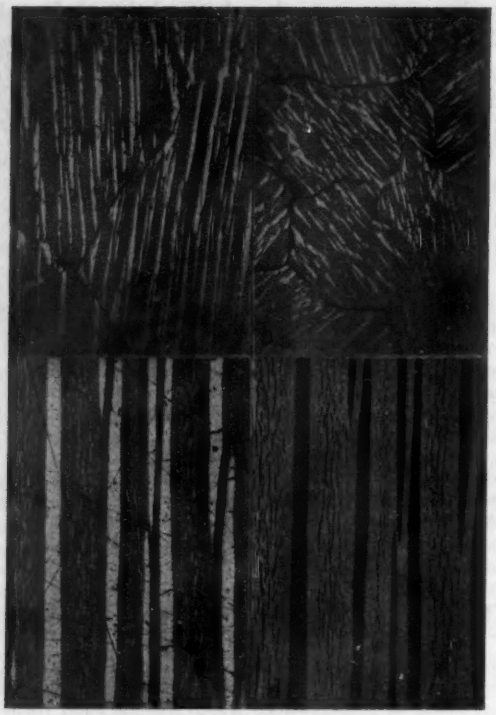

Fig. 1. Polished surfaces of hemoilmenite showing exsolved hematite lamellæ. The direction of the remanent magnetization is from top to bottom in each photograph

shape of thin elliptical disks with one long, one intermediate and one short axis (see Fig. 1).

The hematite lamellæ have exsolved in two distinct size-ranges (see Fig. 1*c*). The simplest explanation for this is that there are two plateaux in the cooling curve of the deposits : a long period of fairly constant temperature during which the large lamellæ exsolved, followed by a relatively rapid drop in temperature, and then a second constant-temperature period during which the small lamellæ were formed. The absence of small lamellæ in the ilmenite adjacent to the large lamellæ indicates a low hematite content, probably due to diffusion of ferric ions from the host into the large lamellæ. There are also small lamellæ of ilmenite in the central part of the large hematite lamellæ. Unfortunately, the steep sides of the hematite–ilmenite solvus curve as given by Nicholls[2] and modified by Uyeda (private communication in 1957 and ref. 3) make it difficult to fix the temperature plateaux accurately. However, the composition of the hematite-rich phase of 0·86 Fe_2O_3, 0·14 $FeTiO_3$ and of the ilmenite-rich phase of 0·87 $FeTiO_3$, 0·13 Fe_2O_3, as given by Uyeda (private communication, 1957) for one sample of Allard Lake ore, indicates a temperature during exsolution of about 700° C. or less. Thus it is not known whether the lamellæ were exsolved before or after they passed through their Curie point, which is about 580° C.

The directions of the remanent magnetization of samples taken from the deposits show a wide scatter, both in the angle of declination and in the magnitude of the angle of inclination, but the signs of the angles of inclination are all negative, that is, the north end of the magnetic vector is inclined above the horizontal. This accounts for the pronounced negative anomalies, in the aeromagnetic survey of the region, over the ilmenite deposits, as reported by Hammond[1] and Bourret[4]. Balsley and Buddington[5] have also reported negative aeromagnetic anomalies over hemoilmenite-bearing rocks in the Adirondacks.

There is a high correlation between the direction of the remanent magnetization of a specimen of the ore and the average direction of the long axes of the hematite lamellæ in the crystals which make up the specimen. In Fig. 1 the remanent vector lies in the polished surface and is directed from top to bottom in each photograph. This correlation between the direction of the remanent magnetization and that of the lamellæ has also been confirmed in single crystals large enough to be measured separately. This suggests that the present remanent magnetization of the ore is due mainly to the hematite lamellæ. Because of the shape effect, the lamellæ should retain only the component of their magnetization parallel to the long axis of each lamella, regardless of the direction of the magnetizing field. This is supported by the difference in intensity of the remanent magnetization of specimens similar in all respects except in the degree of alignment of the directions of the lamellæ from crystal to crystal throughout the specimen. The intensities of the remanent magnetization of the specimens photographed in Fig. 1*a* and 1*b* are, respectively, 0·028 E.M.U./gm. and 0·011 E.M.U./gm. Single crystals have been measured with intensities of more than 0·03 E.M.U./gm. and some massive samples have intensities of less than 0·005 E.M.U./gm.

A further test of the hypothesis that the remanent magnetic field is due to the hematite lamellæ was conducted by dissolving the hematite lamellæ out of the host ilmenite and comparing the intensity of the remanent magnetization before and after solution. Fig. 1*c* shows a typical polished surface and Fig. 1*d* the same surface after the exposed lamellæ of hematite had been dissolved out. Because the lamellæ are discontinuous and completely enclosed in the ilmenite phase, only those exposed on the surface can be dissolved. Thus thin sections of ore were used, ranging in thickness from about 2 mm. to 0·2 mm. Some typical results are shown in Table 1. There was no change in the direction of the remanent magnetization during the solution process. The sections used were cut so that the remanent vector lay in the plane of the section and so that the intermediate axes of the lamellæ were perpendicular to this plane in order to expose a maximum number of lamellæ at the surfaces. The sections with thicknesses of 2 mm. and 0·4 mm. were cut from specimens of typically massive ore of relatively high intensity, whereas the section 0·2 mm. thick was cut from a large single crystal about 12 mm. in diameter.

Since the present remanent magnetization of the ilmenite deposits is due to the exsolved hematite lamellæ and is directed in the average direction of the long axes of these lamellæ, the direction of the remanent magnetization is not necessarily the same

Table 1

Thickness of section (mm.)	Original intensity of magnetization (E.M.U./gm.)	Intensity of magnetization after surface lamellæ dissolved (E.M.U./gm.)	Decrease in intensity of remanent magnetization (per cent)
2·0	0·0264	0·0254	4
0·4	0·0281	0·0033	88
0·2	0·0322	< 0·0002	> 99·6

as that of the Earth's magnetic field which existed while the deposits were being magnetized. If the directions of the crystal axes throughout the deposits were completely random, it should be possible to determine the direction of the Earth's field at the time of cooling of the deposits by averaging the directions of the remanent magnetizations of a large number of samples. Unfortunately, the specimens from the Allard Lake deposits show marked alignment of the *c*, or principal, crystallographic axes of the grains, perhaps due to stress or other geological factors, so that little information about the Earth's field in the past can be obtained by measuring the direction of the present remanent magnetization.

Whereas only the Allard Lake ilmenites have been used in this investigation, it is probable that these results are applicable to other ilmenite deposits or rocks containing ilmenite of similar compositions, perhaps indicating that these rocks should not be used for palæomagnetic work. Investigations are continuing on other aspects of the magnetic properties of the Allard Lake deposits, including the reversed orientation.

[1] Hammond, P., *Econ. Geol.*, **47**, 634 (1952).
[2] Nicholls, G. D., *Advances in Physics*, **4**, 191 (1955).
[3] Uyeda, S., *Jap. J. Geophys.*, **2**, No. 1, 1 (1958).
[4] Bourret, W., *Econ. Geol.*, **44**, 732 (1949).
[5] Balsley, J. R., and Buddington, A. F., *Econ. Geol.*, **53**, 777 (1958).

ABSORPTION SPECTRA AND ASSOCIATED PHOTOCONDUCTIVITY OF PURE AND DECOMPOSED CRYSTALS OF THALLOUS AZIDE

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THE physical and optical properties of thallous azide (TlN_3) suggest that the lattice is predominantly ionic but some sharing of valence electrons occurs. This may be attributed[1] to the large difference in energy between the ionization potential of the thallium atom and the electron affinity of the azide radical. It has been found that thallous azide is a photoconductor when irradiated with light of wave-length corresponding to the fundamental absorption edge.

In the experiments to be described, the crystal of thallous azide was held against two platinum or silver electrodes in such a manner that the incident beam of light irradiated the major morphological face. Measurements were made with the crystal under vacuum and the photocurrent measured as a function of the wave-length of incident light. In addition, measurements have been made to determine the variation of photocurrent with intensity of the light.

The optical absorption spectrum of a single crystal of thallous azide is shown in Fig. 1. In addition to the long-wave-length tail, the absorption spectrum possesses a 'shoulder' in the vicinity of 3000 A. At shorter wave-lengths the absorption rises rapidly to the limit of measurement at 2000 A.

The spectral distribution of photocurrent in a pure crystal of thallous azide is shown in Fig. 2, curve *A*, where the applied voltage gradient was 60 V./cm. There is a subsidiary maximum in the photocurrent at 4300–4350 A. At wave-lengths less than 4000 A. the photocurrent increases rapidly. Measurements could not be made at wave-lengths less than 2600 A. as the output of light from the source used (xenon lamp) is very small at these wave-lengths. If silver electrodes are used instead of platinum electrodes, then the spectral distribution of photocurrent is similar to that of curve *A*, except that the rise in photocurrent at short wave-lengths does not occur until 3600 A.

The crystal used to obtain curve *A*, Fig. 2, was then irradiated, while still under vacuum, through a glass filter, by the output of light from a 100-W. mercury-vapour lamp. The spectral distribution of photocurrent was then measured and is given by curve *B*, Fig. 2. The applied voltage gradient was 160 V./cm. It will be seen that the photocurrent has been reduced to one-tenth of its original value and the rise in photocurrent at short wave-lengths has been eliminated. The maximum photocurrent occurs at 4250 A. The photochemical decomposition resulting from irradiation by the mercury-vapour lamp results in the formation of a thin film of thallium on the surface of the crystal. This metallic film gives rise to a new absorption band. In Fig. 3 the difference in absorption coefficients between an irradiated and pure crystal of thallous azide are plotted. Curves *A*, *B* and *C* of Fig. 3 show how this band develops with increasing time of irradiation.

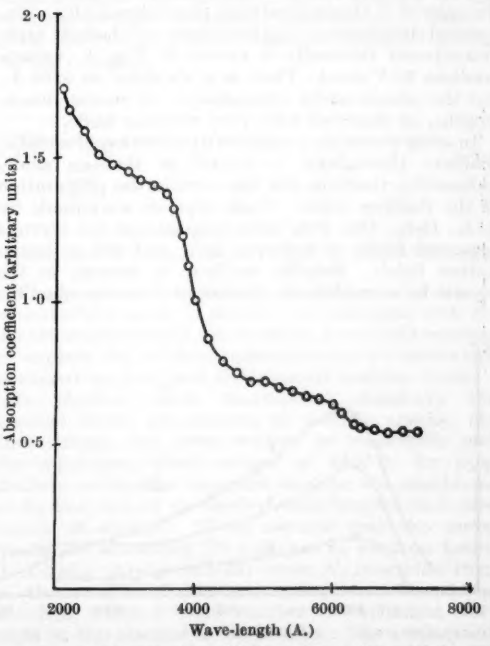


Fig. 1. The absorption spectrum of an undecomposed single crystal of thallous azide

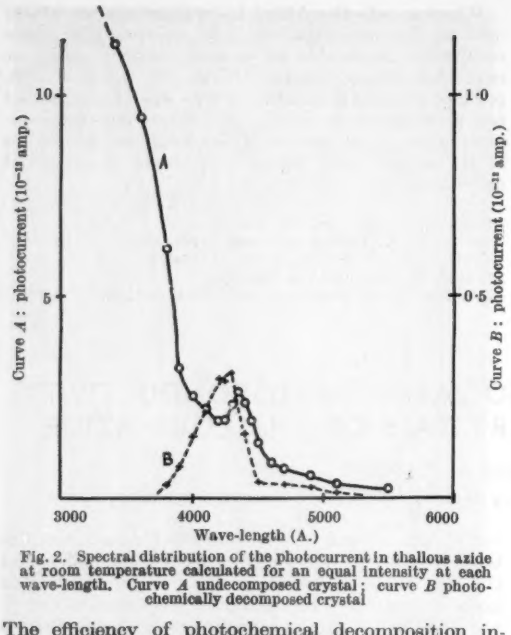


Fig. 2. Spectral distribution of the photocurrent in thallous azide at room temperature calculated for an equal intensity at each wave-length. Curve *A* undecomposed crystal; curve *B* photochemically decomposed crystal

The efficiency of photochemical decomposition increases with decreasing wave-length.

When a crystal of thallous azide (melting point 334° C.) is heated for 10 hr. at 230° C. metal specks are formed at the surface of the crystal. In this experiment, however, the metal is formed as relatively large discrete particles which can be up to 10^{-3} mm. in diameter. These particles appear in a matrix of apparently undecomposed thallous azide and do not give rise to a new absorption band as in the case of thallium produced photochemically. The spectral distribution of photocurrent of thallous azide decomposed thermally is shown in Fig. 4 (voltage gradient 80 V./cm.). There is a 'shoulder' at 4250 A., but the photocurrent rises sharply at shorter wave-lengths, as observed with pure thallous azide.

In order to obtain a uniform distribution of metallic thallium throughout a crystal of thallous azide, radioactive thallium-204 was used in the preparation of the thallous azide. These crystals were made by S. K. Deb. One year after preparation the crystals appeared black in reflected light and red in transmitted light. Metallic thallium is formed in the crystal by a mechanism similar to that described for silver azide[2] and also by irradiation damage due to the fast β-particles that are emitted during decay of the radioactive isotope. The intensity of the light source used in the previous experiments was not sufficient to give rise to a detectable photocurrent in these 'black' crystals. However, by using a 100-W. mercury-vapour lamp in conjunction with filters of narrow wave-band it was possible to show that the general features of the photocurrent – wave-length response resembled that shown in Fig. 4, although on a much reduced scale.

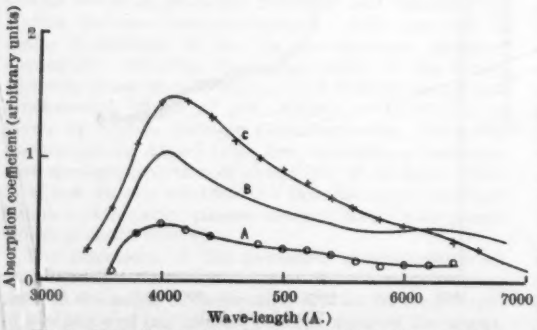


Fig. 3. Absorption spectra of thallium film formed during photochemical decomposition of thallous azide. Curve *A*, crystal irradiated for 1½ hr.; *B*, 4 hr.; *C*, 9 hr.

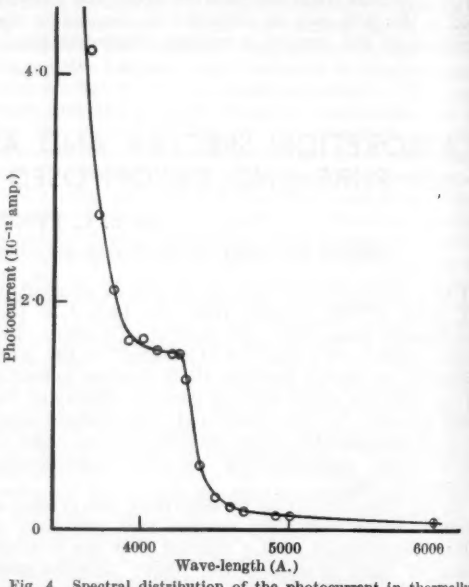


Fig. 4. Spectral distribution of the photocurrent in thermally decomposed thallous azide calculated for an equal intensity at each wave-length

In order to interpret these experimental results we first consider the photoconductivity of pure thallous azide given by curve *A*, Fig. 2. The subsidiary maximum at 4300–4350 A. may be identified with the thermal dissociation of optically formed excitons. The optical transition of electrons from the full band to the exciton band of the crystal gives rise to the 'shoulder' at about 3000 A. shown by the absorption spectrum of Fig. 1. The subsidiary photoconduction maxima are dependent on temperature and it was possible to determine an activation energy for the thermal dissociation of excitons in the thallous azide. The steep rise in photocurrent for wave-lengths less than 4000 A. arises from direct optical transitions from the full band to the conduction band of thallous azide. The corresponding optical absorption for this process is given in Fig. 1 by the steep rise in absorption coefficient at wave-lengths less than 3000 A. Hence over nearly the whole range of wave-length of curve *A*, Fig. 2, the observed photocurrent is the sum of two components. The first component, C_x, having a maximum at 4350 A., is the spectral distribution of photocurrent due to the dissociation of optically formed excitons by the thermal energy of the thallous azide lattice. The second component C_i is the spectral distribution of photocurrent due to direct optical transitions between the full band and conduction band of the crystal. Component C_i may be represented by an equation of the form[3]:

$$\frac{x}{\alpha} = \frac{1}{1 + \exp\{c(\varepsilon_0 - \varepsilon)\}} \quad (1)$$

where c is a constant, ε is the energy of the incident light, ε_0 is the energy at the 'threshold' wave-length and x is the observed photocurrent which increases to a maximum value α (not measured). For $x \ll \alpha$ this equation may be written in the form:

$$\ln_e x = c\varepsilon + \ln_e \alpha - c\varepsilon_0 \quad (2)$$

Curve A, Fig. 2, was plotted as $\ln_e x$ against ε and in this form (Fig. 5) yielded several points of additional information. It will be seen from Fig. 5 that for an incident light energy greater than 3·1 eV. the points of $\ln x$ lie on a straight line which changes to a line having a different slope for energies greater than 3·44 eV. This change in slope at $\varepsilon = 3{\cdot}44$ eV. may be completely accounted for in terms of recombination, of conduction electrons and positive holes. When recombination occurs the electron – positive hole density is high (due to the increasing absorption coefficient) and the equilibrium photocurrent x^1, as measured, is given by $x^1 = x^{1/2}$, where x is the photocurrent that would be measured in the absence of recombination. Hence $\ln x = 2\ \ln x^1$, and if this modification is applied it is found that the points of $\ln x$ for $\varepsilon > 3{\cdot}44$ lie on a straight line having the same slope as that of $\ln x$ against ε for $3{\cdot}1 < \varepsilon < 3{\cdot}44$. This leads to the conclusion that $C_x = 0$ for $\varepsilon > 3{\cdot}1$ and the spectral distribution of C_s can thus be determined for all ε. Knowing the contribution to the observed photocurrent of C_s it is thus possible to plot the spectral distribution of photocurrent due to C_x.

A similar analysis may be made for the photocurrent observed in thermally decomposed thallous azide. It is again found that recombination of electrons and positive holes occurs for C_s when $\varepsilon > 3{\cdot}44$ eV. The spectral distribution of C_x so obtained is found to be identical in form (but reduced in amplitude) when compared with the spectral distribution of C_x for pure thallous azide, except that the maximum, as in Fig. 4, occurs at 4250 A., whereas for undecomposed thallous azide the maximum occurs at 4300–4350 A.

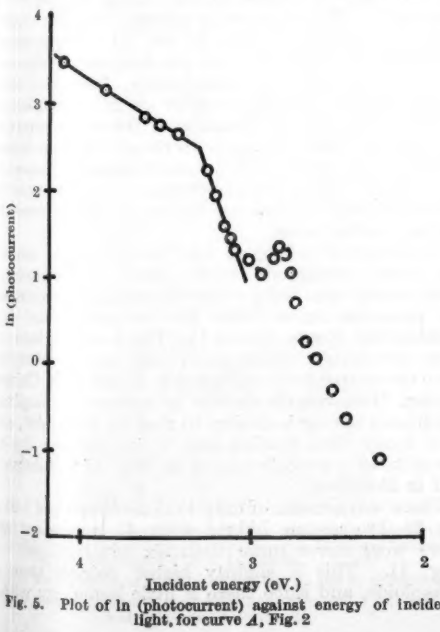


Fig. 5. Plot of ln (photocurrent) against energy of incident light, for curve A, Fig. 2

The spectral distribution of photocurrent obtained with photochemically decomposed thallous azide as given by curve B, Fig. 2, is identical to that calculated for C_x of thermally decomposed thallous azide with the important exception that curve B, Fig. 2, exhibits a long-wave-length tail between 4600 A. and 5200 A.

It has been found, as expected, that the long-wave-length side of C_x for pure and thermally decomposed thallous azide is of the form given by equation 2 and also that electron – positive hole recombination occurs in the vicinity of the maximum. It is therefore likely that the short wave-length decrease in photocurrent of C_x and shown, for example, by curve B, Fig. 2, is due to electron – positive hole recombination. The results so far described may be summarized, for example, with reference to the spectral distribution of photocurrent for undecomposed thallous azide given by curve A, Fig. 2. At long wave-lengths, namely, about 5000 A., the photocurrent due to $C_x + C_s$ is not inhibited by recombination. The absorption steadily increases with decreasing wave-length and the subsidiary maximum at 4300–4350 A. is achieved when recombination limits the rapidly increasing value of C_x. C_x then decreases to zero at 3980 A. (3·1 eV.). For wave-lengths less than 3980 A. the photocurrent is entirely due to C_s and this component is then unaffected by recombination until 3600 A. (3·44 eV.). In the absence of recombination, the photocurrent x will be proportional to I, the intensity of incident light. Where recombination limits the observed value of the photocurrent, then $x \propto I^{1/2}$. In order to verify these predictions involving recombination, the photocurrent of undecomposed thallous azide was measured as a function of the intensity of light at various wave-lengths. Table 1 gives the predicted and observed intensity – photocurrent relations

Table 1

Wave-length (A.)	Predicted	Observed
4650	I	I
4350	$I^{1/2}$	$I^{1/2}$
3800	I	*c.* I*
3350	$I^{1/2}$	*c.* $I^{1/2}$*

* Large error of measurement due to small intensity of light source.

The proposed mechanism of photoconduction in pure thallous azide is able to account quite well for the observed spectral distribution, but it still remains to explain the different photoconductive behaviour exhibited by pure and decomposed thallous azide.

In thallous azide decomposed thermally the metallic nuclei are present as discrete specks, the photocurrent has been reduced in magnitude and the minimum, which occurs at 4250 A. for pure thallous azide, has been lost because the maximum of C_x has moved to shorter wave-lengths and now occurs at 4250 A. If we assume that the metal specks, by attracting Tl^+ ions, act as electron traps, then if the number of such traps, N, is smaller than x^1, the number of conduction electrons, then $x^1 = x - N/2$, where x is the number of conduction electrons in the absence of such traps. The consequent reduction in density of conduction electrons will (*a*) reduce the observed photocurrent, and (*b*) move

the maximum of C_x to shorter wave-lengths as the reduced electron density will delay the onset of recombination.

In the case of radioactive thallous azide the very large number of submicroscopic metal specks will lead to an overall reduction in photocurrent due to the increased absorption and the large number of traps. The spectral distribution of photocurrent should be as in Fig. 4, and this is what is observed.

Photochemically decomposed thallous azide, however, possesses a large number of metal traps in the form of a metal film on the surface of the crystal. This metal film also reduces the amount of light absorbed by the crystal in the region of C_x. The rise in photocurrent for short wave-lengths has been completely eliminated due to the metal electron traps. Similarly, as in the case of thermally decomposed thallous azide, the maximum of C_x has moved to shorter wave-lengths. However, the photocurrent has a long-wave-length tail and this arises from C_s. The metal film is not effective as an electron trap at these longer wave-lengths about 5000 A. because of the small absorption of the thallous azide. This means that the photoelectrons are produced some distance below the crystal surface.

In conclusion, it must be noted that if an 'undecomposed' crystal of thallous azide is irradiated on one of the minor morphological faces, then the spectral distribution of photocurrent is the same as that shown in curve *B*, Fig. 2. It has been found, however, that such crystal faces are far more sensitive to photochemical decomposition than the major faces, presumably due to their higher surface energy. Crystals examined in this manner have undoubtedly undergone some photochemical decomposition.

[1] Evans, B. L., and Yoffe, A. D., *Proc. Roy. Soc.*, A, **238**, 568 (1957).
[2] Deb, S. K., Evans, B. L., and Yoffe, A. D., *Nature*, **180**, 294 (1957).
[3] Moss, T. S., "Photoconductivity in the Elements" (Butterworth, London, 1952).

GENETIC CONTROL OF CHROMOSOME PAIRING IN INTERGENERIC HYBRIDS WITH WHEAT

By Dr. RALPH RILEY, VICTOR CHAPMAN and GORDON KIMBER
Plant Breeding Institute, Cambridge

It has been shown that in hexaploid common wheat, *Triticum vulgare* ($6x=42$), control of the purely bivalent-forming, diploid-like, meiotic behaviour is exercised by a gene, or genes, on one particular chromosome[1]. In the absence of this chromosome, pairing can take place between equivalent, homœologous, chromosomes in each of the three genomes, so that wheat ceases to behave as a classical autosyndetic allopolyploid. The diploidizing mechanism was exposed by Riley and Chapman in studies of 20-chromosome nullihaploids and 40-chromosome nullisomics in the variety Holdfast[1,2], and was indicated in the simultaneous work of Sears and Okamoto[3] on crosses of monosomics of the variety Chinese Spring with diploid wheat.

Chromosome V of Chinese Spring carries the gene responsible for the restriction of homœologous pairing but it has not yet been possible to confirm, by crossing, that the Holdfast chromosome, designated *HH*, with the equivalent effect is homologous with V of Chinese Spring. This is very likely, however, since both nullisomics have similar deviations from the euploid phenotypes, and it is known that the phenotype of nullisomic V is very different from those of all the other nullisomics of Chinese Spring[4]. Moreover, both chromosomes are similar in morphology, being heterobrachial with one arm about twice the length of the other.

The utilization of the variation of many diploid species in the genus *Aegilops*, and of *Secale* species, in the improvement of wheat is limited because there is little or no pairing between the chromosomes of wheat and those of the diploids with which wheat is combined in intergeneric hybrids, so that foreign genes cannot be introduced into wheat chromosomes by recombination. Riley and Chapman suggested that the genetic mechanism which restricts pairing between homœologous chromosomes of wheat might also be responsible for the failure of wheat chromosomes to pair with those of some species in related genera. If this were so, intergeneric hybrids deficient for the chromosome carrying the diploidizing control would have some chromosomes of wheat paired with some of those of the diploid parent. To test this hypothesis the crosses *T. vulgare* Chinese Spring monosomic V ($6x-1=41$) × *Aegilops longissima* ($2x=14$) and *T. vulgare* Chinese Spring monosomic V ($6x-1=41$) × *Secale cereale* King II ($2x=14$) were made. The monosomic parents in these crosses produced gametes with 20 or 21 chromosomes depending on whether or not the monosomic chromosome was included. Consequently, from the same female parent, hybrids with 27 or 28 chromosomes resulted from the combination of the seven chromosomes of the male gamete with the alternative female gametes. Hybrids with 28 chromosomes possessed, and those with 27 chromosomes did not possess, chromosome V of Chinese Spring which carries the pairing control gene.

Chromosome pairing at first metaphase of meiosis has been compared in 27- and 28-chromosome hybrids and data from a few of the plants examined are presented with those for euhaploid and *HH* nullihaploid plants (Table 1). The haploid data are those previously collected in the variety Holdfast since no comparable material was available in Chinese Spring. However, the meiotic behaviour of euhaploids in Chinese Spring is similar to that in Holdfast[2], and it is likely that nullihaploid V in Chinese Spring would have a meiosis similar to that of nullihaploid *HH* in Holdfast.

There was a mean of only 1·96 bivalents per cell in the 28-chromosome hybrid with *A. longissima* and there were never more than six bivalents per cell (Fig. 1). This is slightly higher pairing than in euhaploids, and since there is little homology within

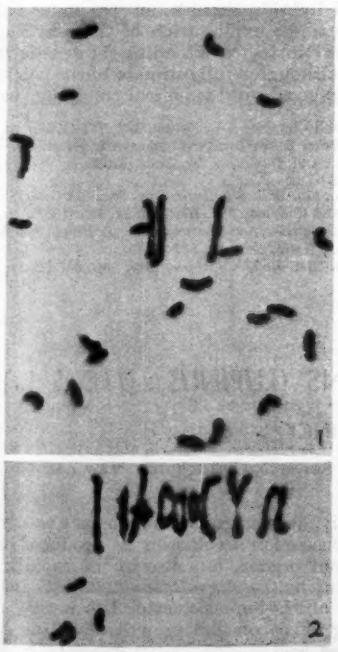
Table 1. Meiotic Chromosome Pairing in Haploids and Hybrids of *T. vulgare* with and without the Chromosome Conditioning Diploid Meiotic Behaviour

Plant	Chromosome No.	Cells	Mean pairing				Range of chromosomes conjugated
			Univalents	Bivalents	Trivalents	Quadrivalents	
Euhaploid Holdfast	21	100	18·05 ± 0·20	1·38 ± 0·09	0·07	—	0–9
Nullihaploid Holdfast	20	75	9·02 ± 0·28	4·16 ± 0·12	0·86 ± 0·03	0·02	4–19
C. Spring × *A. longissima* 1	28	100	23·96 ± 0·23	1·96 ± 0·06	—	—	0–12
C. Spring × *A. longissima* 2	27	100	9·85 ± 0·33	6·45 ± 0·19	0·87 ± 0·09	0·41 ± 0·05	10–24
C. Spring × *A. longissima* 3	27	100	7·50 ± 0·35	7·58 ± 0·23	0·70 ± 0·08	0·56 ± 0·05	10–27
C. Spring × *S. cereale* 1	28	100	25·26 ± 0·21	1·37 ± 0·03	—	—	0–8
C. Spring × *S. cereale* 2	27	100	18·00 ± 0·26	3·18 ± 0·13	0·70 ± 0·09	0·11 ± 0·03*	4–17
C. Spring × *S. cereale* 3	27	100	17·83 ± 0·37	2·82 ± 0·14	0·89 ± 0·09	0·15 ± 0·05†	2–21

* Plus 2 associations of five.
† Plus 1 association of seven, 1 of eight and 1 of eleven.

the haploid complement of *A. longissima*[5] a small amount of pairing between wheat and *Aegilops* chromosomes must be indicated.

By contrast, chromosome pairing in the 27-chromosome hybrids with *A. longissima* was very high (Fig. 2). There were never fewer than 10 chromosomes paired and in some cells no chromosomes were left unpaired. The mean univalent frequency was almost the same as that of the 20-chromosome *HH* nullihaploid, so that the seven extra chromosomes were evidently often involved in pairing. Compared with the nullihaploid the mean bivalent frequency increased by more than half and the mean quadrivalent frequency increased 20 times, while there was about the same amount of trivalent formation. The frequent quadrivalents must have arisen from the conjugation of three homœologous chromosomes of some wheat groups with the equivalent *A. longissima* chromosomes. Apparently, therefore, the chromosomes of *A. longissima* will pair with those of wheat to a greatly increased extent when chromosome V is absent. For although quadrivalents are the only certain indication, presumably wheat and *Aegilops* chromosomes were also associated in bivalents and trivalents.



First metaphase of meiosis in Feulgen and orcein stained squashes of pollen mother cells of hybrids from the cross *T. vulgare* Chinese Spring monosomic V × *A. longissima*. (× 780)

Fig. 1. 28-chromosome hybrid with 3 bivalents and 22 univalents

Fig. 2. 27-chromosome hybrid with 1 quadrivalent, 1 trivalent, 8 bivalents and 4 univalents

The close relationship between *A. longissima* and *Aegilops speltoides*, the contributor of the *B* genome of *T. vulgare*, has been indicated by Riley, Unrau and Chapman[6]. Furthermore, the cytological affinity of all the genomes of wheat is shown by the intergenome pairing in *HH* nullihaploids, and from the pairing in hybrids between the putative diploid parents[1]. It is not surprising, therefore, that there is a close relationship between the chromosomes of *A. longissima* and those of each of the genomes of wheat. It is, however, remarkable that this affinity could normally be obscured by the diploidizing mechanism on chromosome V.

The amount of chromosome pairing in 28-chromosome hybrids between monosomic V and rye was not higher than that in euhaploid *T. vulgare* (Table 1). There is thus probably no pairing between wheat and rye chromosomes in normal hybrids. However, while there was much more pairing in the 27-chromosome hybrids from the same parents, and as many as 21 chromosomes could be involved in associations in one cell, there were on average fewer chromosomes paired than in *HH* nullihaploids of Holdfast. The 27-chromosome plants showed means of about one fewer bivalents per cell and this may reflect some interference, by rye, with pairing which occurs in nullihaploids. It is also possible, however, that the apparent differences may have resulted from the selection of cells scored, which was often compelled by the difficulty of interpreting cells with much pairing due to the attenuated and clumped nature of the chromosomes in rye hybrids deficient for chromosome V. The appearance of the chromosomes was normal in 28-chromosome hybrids with rye and in both types of *A. longissima* hybrid.

However, in the 27-chromosome hybrids there was about the same number of trivalents as in nullihaploids, but more than four times as many quadrivalents. The quadrivalents must have resulted from associations of homœologous chromosomes from each of the three genomes of wheat with a rye chromosome. Since rye chromosomes could pair with wheat chromosomes in quadrivalents it may be that they were also conjugated with wheat chromosomes in bivalents and trivalents. However, the frequency of rye–wheat pairing must have been low compared, for example, with the amount of *A. longissima*–wheat pairing. Nevertheless the evidence of quadrivalents alone is sufficient to show that, in the absence of V, rye and wheat chromosomes can pair, even though this rarely, if ever, happens in euploid hybrids.

Furthermore, in the 27-chromosome hybrids with rye, there were some large complexes, associated by chiasmata, and involving up to eleven chromosomes. These occurred in about five per cent of first metaphase cells but were often so complex that they defied interpretation and so such cells are underrepresented in the analyses recorded. The large complexes probably arose because there is not a strict one-to-one relationship between rye chromosomes and wheat homœologous groups; rather, certain rye chromosomes must have affinities with the chromosomes of two wheat groups. That is, the rye chromosomes differ from chromosomes of the wheat groups by translocations, and for associations of more than eight to occur the rye complement must differ from the wheat genomes by at least two translocations involving three pairs. Annual rye differs from perennial rye by two translocations involving three chromosome pairs[7]. If the translocations which differentiate the rye species are the same as those which differentiate annual rye from the wheat genomes, then there would be no associations larger than quadrivalents in 27-chromosome hybrids involving perennial rye. If this could be shown it would indicate the primitive structure of the perennial rye genome and the derived nature of the annual rye genome, and so would clarify the general understanding of the origins and phylogeny of cultivated rye.

The chromosomes of rye and *A. longissima* show marked differences in their capacity to pair with wheat chromosomes in the absence of chromosome V. In view of the present evidence on the genetic control of pairing, the dangers of drawing phylogenetic conclusions from pairing in hybrids are apparent. Nevertheless, the differences between the rye and *Aegilops* derivatives may, with caution, be taken to indicate the greater evolutionary divergence of rye and wheat, compared with *Aegilops* and wheat, further evidence of which is the failure of rye chromosomes fully to match the wheat groups.

The present evidence on the powerful influence of the diploidizing control of hexaploid wheat on chromosome pairing in hybrids leads to two main conclusions. First, it is apparent that the possible influence of genetic situations such as that in wheat must be taken into consideration whenever chromosome pairing in hybrids involving polyploids is used in the interpretation of phylogenetic relationships. The chromosome pairing in crosses with polyploids should be compared with that in hybrids with the diploids from which the polyploids were derived. The effect of genes isolating the genomes of the polyploids and interfering with the expression of pairing affinities at meiosis might then be detected.

Secondly, since it is apparent that the barrier to the pairing and recombination of wheat chromosomes and those of some related species in other genera can be removed by the exclusion of chromosome V, the reservoirs of genetic variation upon which the wheat breeder can now draw are greatly increased. All the diploid species of wheat and *Aegilops* are comparatively closely related and have chromosomes capable of pairing in diploid hybrids[8], so that this complete group can be regarded as a single pool from which genes may be extracted and incorporated on wheat chromosomes by recombination. This process will be limited only by the capacity to make appropriate crosses and to devise means of handling the hybrid material. Numbers of manipulations of 27-chromosome material are possible. Hybrids may be backcrossed directly with wheat, or may be treated with colchicine to produce 54-chromosome, multivalent-forming amphiploids also to be used in back-crossing. These amphiploids may be infertile and hard to maintain, and it will then be necessary to use the amphiploid sectors on the original *F*1 plants treated with colchicine for back-crossing.

Similar techniques may be used to exploit the pairing which can be induced between rye chromosomes and wheat chromosomes. Consequently it may, at last, be possible to combine rye and wheat without resorting to breeding amphiploids or whole chromosome addition and substitution lines. The complications to be overcome in handling the derivatives of nulli-V hybrids should not be under-estimated. Nevertheless the exploitation of these hybrids holds unique possibilities for extending the genetic variation of wheat, although a full estimate of the potentialities must be deferred until genetical results are available.

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ABSCISSION-ACCELERATORS IN LUPINS (*LUPINUS LUTEUS* L.)

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In nearly all recent publications the initiation of abscission is considered to be primarily controlled by auxin[1–4]. Osborne[5,6], however, was the first to publish evidence that an abscission-accelerating factor other than auxin is produced in senescent leaves or with induced senescence of normal green leaves. This natural abscission factor was found to counteract the abscission-delaying effect of indolylacetic acid in bean explants and was claimed not to be a sugar, amino-acid, purine or pyrimidine.

Recently, it was found in our laboratory that a natural abscission-accelerator is produced not only in senescent organs, but also in the rapidly growing fruits of lupins (*Lupinus luteus* L. var. Weiko II), and that this abscission-accelerator has a very powerful inhibiting effect on the growth of wheat coleoptile sections as well.

Young pods were collected seven days after flowering, when they were quite small (mean weight 135 mgm.), but had just entered their period of rapid growth, and were most active in inducing abscission

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of further flowers[7]. The purification of ether extracts, chromatography and coleoptile straight-growth test were the same as reported recently[8]. The results of one chromatogram of the acid fraction of such an extract are illustrated in Fig. 1, and this shows the presence of one growth promotor (*A*) ($R_F = 0{\cdot}4$–$0{\cdot}5$), and of one powerful inhibitor (*B*) ($R_F = 0{\cdot}55$–$0{\cdot}75$; solvent isopropanol : 25 per cent ammonia : water = 8 : 1 : 1).

Although *B* caused up to 90 per cent inhibition of coleoptile extension (the residual growth occurred mainly during the 2-hr. soaking period of the cut sections), it did not appear to have a toxic effect, the sections did not change colour, remained fully turgid, and were capable of assuming growth at a rapid rate after rinsing them in distilled water and adding indolylacetic acid to the medium. Yet, the activity of *B* in lupin pods was 1,000 times greater than that of inhibitor β from an equal amount of etiolated pea seedlings extracted under identical conditions[8].

Interactions between various concentrations of *B* and indolylacetic acid were measured, and some of the results in Fig. 2 show that the effect of *B* can be counteracted by certain concentrations of indolylacetic acid, amounts of 1 and 3 μgm. indolylacetic acid per ml. being able to neutralize the inhibiting effect of *B* extracted from 230 and 700 mgm. of tissue, respectively.

A and *B* were extracted separately from their corresponding areas on the chromatograms, to test their activity in the lupin abscission test, which essentially was an adaptation of Addicott's bean abscission test[9]. The explants used in our test consisted of a 2-cm. section of the main flower stalk

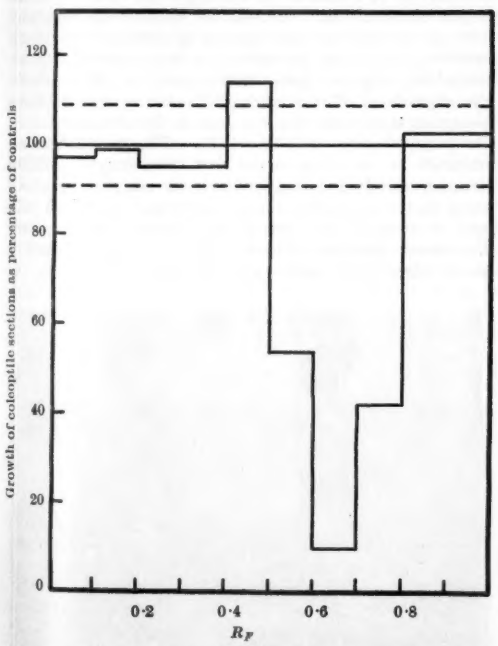

Fig. 1. The response of wheat coleoptile sections to chromatogram strips prepared from the acid fraction of an extract of 10 gm. of lupin pods. Solvent, isopropanol : ammonia 25 per cent : water (8 : 1 : 1). Growth plotted as a percentage of growth of control sections (8·41 mm. over a period of 17½ hr.). The broken line represents the level at which differences were significant ($P = 0{\cdot}05$)

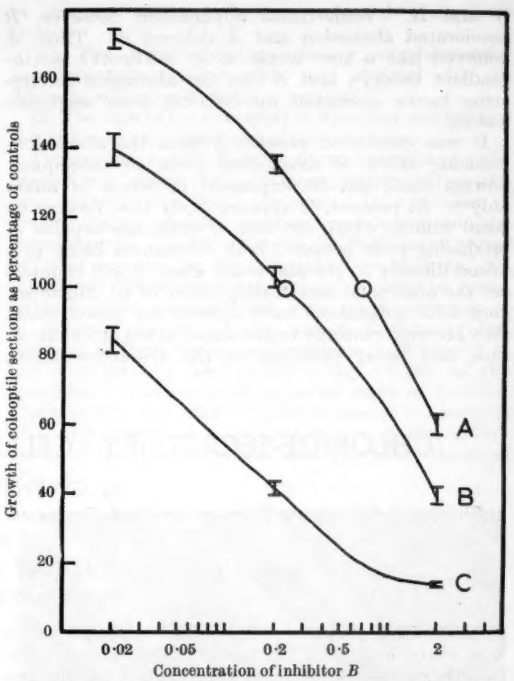

Fig. 2. The effects of various amounts of indolylacetic acid in alleviating the growth inhibition caused by various amounts of inhibitor *B* (all quantities per 1 ml. medium; vertical lines = 2 × standard error). Curve *A*, 3 μgm. of indolylacetic acid; *B*, 1 μgm. of indolylacetic acid; *C*, no indolylacetic acid added. Abscissa, the equivalent fresh weight of tissue (gm.) from which inhibitor *B* was extracted

with the five pedicels half way, and the flowers removed. Directly after cutting, the explants were placed upright in 5-mm. thickness of 2 per cent agar, which was allowed to set in 9-cm. crystallizing dishes, covered by a Petri dish lid. The purified extracts were reduced in volume and applied to punched paper disks in a wide range of concentrations, or they were mixed with small quantities of lanolin paste, which were then applied to the explant, either to one of the proximal sides (the physiological base of the flower stalk, because substances were preferably translocated in apical direction), or to the distal side of the abscission zone (cut end of the pedicel).

Results in Table 1 show that with proximal application abscission is accelerated by both substances

Table 1. Effect of Two Endogenous Growth Substances in Lupins on the Number of Hours Required for 50 per cent and Complete Abscission, Respectively

	Hr. to 50 per cent abscission	Hr. to complete abscission
Proximal application		
Control	81·4	115
Inhibitor *B* equivalent to 5 gm. of tissue	64·5	84·5
Inhibitor *B* equivalent to 1 gm. of tissue	81·9	97·5
Promotor *A* equivalent to 5 gm. of tissue	74·9	93·5
Promotor *A* equivalent to 1 gm. of tissue	81·1	100
Distal application		
Control	87·2	134
Inhibitor *B* equivalent to 250 mgm. of tissue	72·0	89
Promotor *A* equivalent to 500 mgm. of tissue	130·5	—

A and *B*. With distal application, however, *B* accelerated abscission and *A* delayed it. Thus, *A behaved like a true auxin as in Addicott's auxin-gradient theory*[1], and *B* like the abscission-accelerating factor extracted by Osborne *from senescent* leaves.

It was concluded previously that the abscission-*inducing effect of developing pods on subsequent* flowers could not be explained in terms of auxin only[10]. At present, it appears likely that *flowers on* basal whorls, which are first to open, are capable of producing pods because, both substances being pro*duced distally to the abscission* zone, *A* will counteract the abscission-accelerating effect of *B*. However, once both substances have entered the *flower stalk*, they are preferentially translocated in the apical direction, and being proximal to the abscission zones, they both would be expected to co-operate in accelerating abscission of further flowers.

Further details of this work, and of comparisons made between virus-infected (low incidence of *abscission) and healthy plants, and of changes* occurring during the development of pods will be reported elsewhere.

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'CHLORIDE-SECRETORY' CELLS IN THE GILLS OF TELEOSTS

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CURRENT theories concerning the regulation of water and salts by teleost fishes involve the hypothesis that some ions, principally chloride, are transported against the concentration gradient into a freshwater fish and out of a marine fish. The ability of certain acidophil cells in the gills to bring about this ion movement has come to be generally accepted, although the original claim for this function of the acidophil cells[1] has been contested more than once. Keys and Willmer described the undeniable existence of large numbers of secretory cells in the gills of eels and other teleosts (Fig. 1: all sections were stained with hæmatoxylin-eosin and alcian blue). They estimated that there were between 3 and 6 million cells in an eel weighing 250 gm. and that they constituted "a probable and even possible histological basis for branchial chloride excretion" which had previously been demonstrated[2,3]. The elasmobranch *Scyliorhinus* was found to lack these cells in the gills, which accorded well with the interpretation of osmoregulation in these fish. Experimental evidence for a salt-regulating function for the cells was put forward by Liu[4], who found that their development was favoured by a gradually increasing salt concentration.

Observations on the estuarine mudfish *Fundulus* gave support to the 'Keys-Willmer' theory[5,6], and Getman[7] similarly found differences between secretory and absorptive phases of the cells in the eel. Copeland and Pettengill[8] together demonstrated that enzymic activity could be localized within the cells, thus providing a possible physiological mechanism for chloride exchange.

More recently, Vickers[9] has suggested that the cells represent a metaphasic form of mucous cells. The gradual acclimatization of fish to high external salinities induced the development of the cells. Histological changes were associated with the secretory phase. A large amount of circumstantial evidence has thus been accumulated in favour of a chloride-secretory function.

There has also been some criticism of the 'Keys-Willmer' theory. Krogh[10] was sceptical of a chloride-secretory function of the cells and the absence of any direct evidence justifies this. Bevelander[11] made a comparative study of many fish and suggested that the 'chloride-secretory' cell was a mucous cell. The work of Copeland and Pettengill on *Fundulus* to some extent discredited Bevelander's study; but it is interesting to recall it in the light of Vickers's more recent conclusions. Bevelander found the acidophil cells in the mucous membranes of the mouth and gill cavities, and their presence in the general buccal-branchial region was confirmed in *Fundulus*[12]. Investigations of the acidophil cells in teleosts have demonstrated that their greatest development is in the pseudobranch[13] (Figs. 1–3). The pseudobranch, whether it is represented by the simple gill-like structure in the herring, or the more complex enclosed mass in the salmon, consists of large acidophil cells held compactly by connective tissue, with a well-developed capillary blood supply. This picture is essentially the same in marine, freshwater or

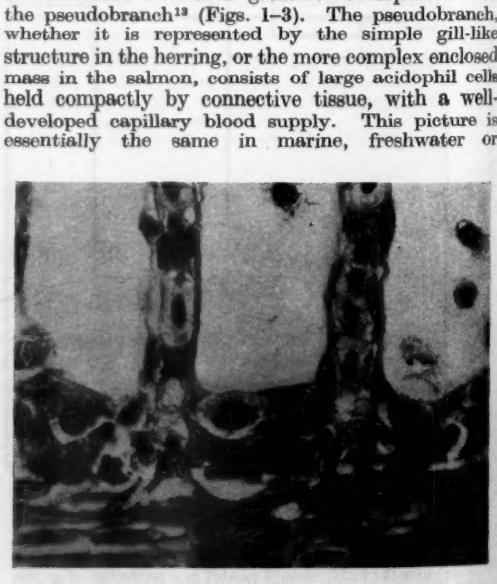

Fig. 1. Photomicrograph of T.S. gill lamellæ of salmon smolt in fresh water to show detail of acidophil cells. (× c. 700)

Fig. 2. Photomicrograph of T.S. pseudobranch of young herring in sea water. (× *c.* 600)

migratory species. The acidophils of both gills and pseudobranch are regarded as the same cells[18]; if their identity is established, then it is important to reconsider their function.

The presence of similar acidophil cells in both freshwater and marine teleosts presents another aspect of the problem. Some of the authors quoted have seen histological changes, and attributed them to changes in the polarity of the cells, when the fish are living in different environments. The presence of the cells in regions where they could not function as chloride regulators and their apparent absence in newly hatched fish larvæ, where regulation takes place, also create doubts as to the general validity of the theory. The anatomical disposition of the pseudobranch, for example, is such that the blood supply is from the first efferent gill artery; within the pseudobranch it becomes a capillary network; and after anastomosis it goes principally as an ophthalmic artery to the eye. Thus, the blood reaching the pseudobranch has already passed the respiratory and ion-regulating gills. It must be fully oxygenated, with no appreciable load of bicarbonate which could be broken down by the carbonic anhydrase present. The acidophil cells of the pseudobranch and other parts of the branchial region thus have a very different internal environment from those in the gills. In addition, while the pseudobranch hangs freely into the branchial cavity in a few teleosts, in many it has sunk below the epidermal surface.

Experiments designed to investigate the function of the pseudobranch in some teleost fishes are in progress and are being conducted along two lines:

(1) The osmoregulatory ability of bilaterally pseudobranchectomized fish and normal fish in different salinities is being compared.

(2) The rate of ion transport in operated and normal fish is being compared, using radio-isotopes.

Preliminary results do not suggest that the pseudobranch is a major site of osmoregulation within the range of salinities 0–3·5 per cent. In a number of species (*herring, saithe, sea trout, rainbow trout*) the pseudobranch can be removed on both sides either by heat cautery or by a surgical technique. No significant difference in survival-times could be found between those sea water fish replaced in sea water or in isotonic medium (⅓ *sea water*), freshwater fish replaced in fresh water, and controls. All species of fish were seen to feed within a day or two of the operation; there were no external signs of distress. The majority of the fish are still alive some 2–3 months after the operation, and no increase in the acidophils of the gills of these fish has been observed (*Fig.* 4).

Fig. 3. Photomicrograph of T.S. pseudobranch of salmon smolt in fresh water. (× *c.* 600)

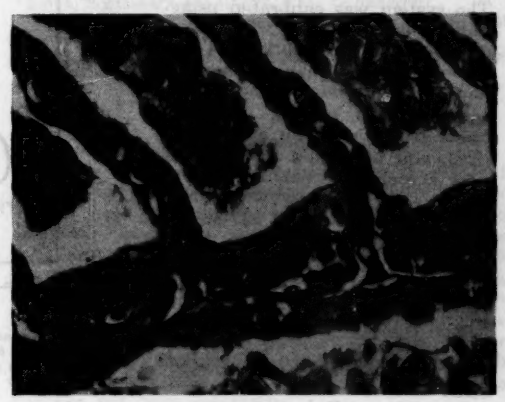

Fig. 4. Photomicrograph of T.S. gill lamellæ of adult sea trout in sea water three months after pseudobranchectomy. (× *c.* 600)

Since the fish appear to achieve osmoregulation in fresh water or sea water after pseudobranchectomy, should we conclude that the cells of the gills alone are able to cope with osmotic stresses of the magnitude?

If the cells of the pseudobranch do not function as chloride-regulators, we are justified, in the absence of any direct evidence, in asking if the very similar cells of the gills do act in this way. In short, are the acidophils of both gills and pseudobranch concerned with salt-exchange at all? It is hoped that a more complete investigation of the function of the pseudobranch will help to answer this question.

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LETTERS TO THE EDITORS

PHYSICAL SCIENCES

A High-resolution Survey of the Andromeda Nebula at 408 Mc./s.

In December 1958 observations of the Andromeda Nebula were made using the 250-ft. radio telescope at Jodrell Bank[1]. A Dicke type radiometer, pass-band 408 ± 2 Mc./s., noise figure 6 db., was used. The beam was elliptical, having half-power widths of 40 and 56 min. of arc. The system was calibrated using radio source 14*N*5*A*, which was assumed to have a flux[2] of 47 × 10^{-26} W.m.$^{-2}$ (c./s.)$^{-1}$. Figs. 1, 2 and 3 show the intensity contours of the nebula, averaged scans along the major and minor axes, and an actual record of a scan through the nebula.

Previous lower-resolution surveys at 158 Mc./s. and 237 Mc./s. have shown[3,4] that the radio emission from the nebula can be divided into two components, one co-extensive with the visible nebula called the disk component, and accounting for 10 per cent of the total emission, and the other a much broader elliptical component, called the corona, extending over 10° along the major axis and 6° along the minor axis.

The outstanding new feature shown by this high-resolution survey is the complex structure of the corona, in particular the spur-like extensions away from the major axis (Fig. 1). Some structure is also seen in the radiation from the disk component. The greater part of the radio emission from the disk lies above the dotted line on the minor axis scan (Fig. 2) and appears to come from a source coincident with the optical centre. This peak is not broader than the beam, so that an upper limit of 35 min. of arc can be set for the diameter of this central source of radiation. At the points marked by arrows on the major-axis scan in Fig. 2, the profiles of optical and radio emission both show a change of slope. It is interesting to note that this is the brightest part of the spiral-arm structure of the nebula.

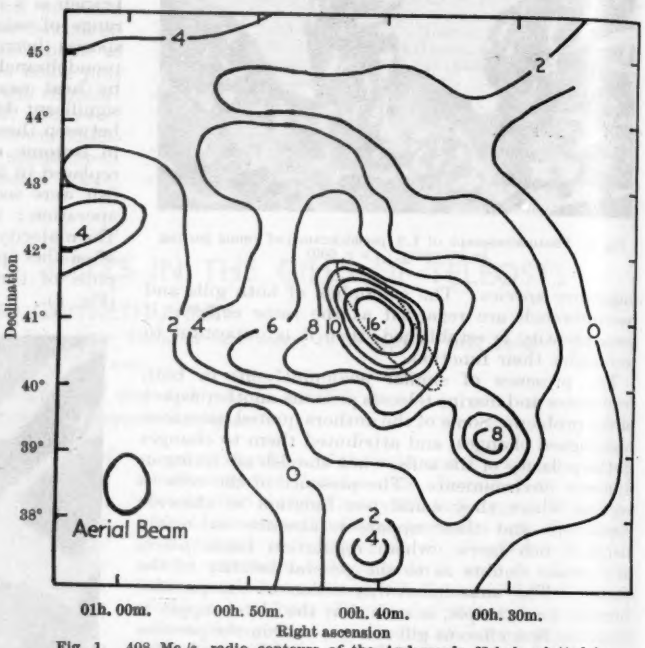

Fig. 1. 408 Mc./s. radio contours of the Andromeda Nebula plotted in intervals of 2 deg. K. brightness temperature, indicating the temperature above a chosen reference region, R.A. 00h. 15m., dec. + 38°. The dotted ellipse shows the 24·05 mag.²/sec.² contour taken from a recent photometric survey by de Vaucouleurs (ref. 8) of the nebula. The co-ordinates are for epoch 1950.0

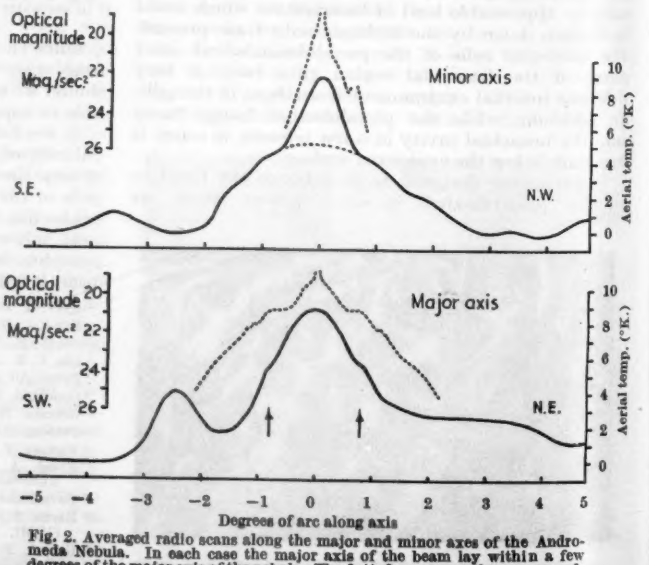

Fig. 2. Averaged radio scans along the major and minor axes of the Andromeda Nebula. In each case the major axis of the beam lay within a few degrees of the major axis of the nebula. The dotted curves are the corresponding photometric profiles obtained by de Vaucouleurs (ref. 8)

Fig. 3. A typical drift curve through the Andromeda Nebula at + 40° 15′ declination

Assuming that the corona extends to the 2° K. contour (Fig. 1) the total emissivity is 140×10^{-26} W.m.$^{-2}$ (c./s.)$^{-1}$, of which the disk component contributes 8×10^{-26} W.m.$^{-2}$ (c./s.)$^{-1}$. The general background temperature has been assumed to be 1 deg. K. above the reference temperature, and this has been subtracted before measuring the emissivity. The extended 'plateau' to the north of the nebula has been included, although it is not certain that it is associated with the nebula.

The radio sources (R.A. 00h. 31m. 45s., dec. + 39° 12′, flux $4{\cdot}5 \times 10^{-26}$ W.m.$^{-2}$ (c./s.)$^{-1}$; R.A. 00h. 34m. 30s., dec. + 38° 24′, flux $1{\cdot}5 \times 10^{-26}$ W.m.$^{-2}$ (c./s.)$^{-1}$) have been assumed not to lie in the nebula, and their emissions have been subtracted in deriving the figure for the total emissivity. The source (R.A. 00h. 40m. 30s., dec. + 37° 36′) lies outside the assumed limits of the corona. It has a flux of 3×10^{-26} W.m.$^{-2}$ (c./s.)$^{-1}$.

The fainter satellite of Andromeda, N.G.C. 205 (R.A. 00h. 37m. 40s., dec. + 41° 25′), is an irregular elliptical galaxy (E_5, $m_p = 8{\cdot}9$)[5]. No radio emission has yet been detected from an elliptical galaxy or any similar structure (for example, a globular cluster) devoid of interstellar gas[6]. It is important to decide how much elliptical galaxies radiate relative to normal spiral galaxies, so that the importance of interstellar gas in the production of radio radiation may be assessed. An upper limit of 2×10^{-26} W.m.$^{-2}$ (c./s.)$^{-1}$ may be placed on the flux from N.G.C. 205 at 408 Mc./s., by examination of the contours in Fig. 1. This is less than 70 per cent of the radiation from a normal spiral galaxy having the same photographic magnitude. This calculation is based on a value given by Hanbury Brown and Hazard (private communication) for 158 Mc./s. radiation, that $m_r - m_p$ is equal to 0·5 for normal S_b galaxies, if m_r is defined as $m_r = -53{\cdot}45 - 2{\cdot}5 \log S_{158}$. The spectral index is taken to be $-1{\cdot}1$.

The nature of the spur-like extensions of the contours (Fig. 1) is at present a matter for speculation. In the left-hand spur, some indication of fine structure is seen in the original records. The records show two sources of a few flux units at positions R.A. 00h. 46m. 15s., dec. + 40° 24′ and R.A. 00h. 52m. 00s., dec. + 40° 30′. If these sources are subtracted, the spurs then appear symmetrical. Similar north and south polar spurs have been detected in the radio emission from our own Galaxy[7], and although they are not as prominent as the spurs in Andromeda, it is possible that such spurs are structural features common to spiral galaxies. In Andromeda, the angle made by the line of extension of the spurs to the minor axis is what would be expected if the synchrotron mechanism[8] were responsible for the emission. This suggests that the magnetic fields in the corona of the nebula may be ordered, and related to the spiral arm structure.

We thank Prof. A. C. B. Lovell for making available the facilities at Jodrell Bank, and Mr. R. Hanbury Brown and Dr. C. Hazard for suggestions and criticisms throughout the course of the work. One of us (D. S. M.) gratefully acknowledges a Leverhulme Research Fellowship.

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Fine Iron Filaments Magnets

It has been known for many years that a body containing parallel elongated and suitably equispaced iron particles, each of about 0·02μ cross-sectional diameter, should theoretically possess excellent permanent magnetic properties. To the best of our knowledge, all attempts at producing materials with the desired structure have relied on the manufacture and compacting of submicroscopic iron particles. Although the results have been of considerable scientific and commercial interest, the desired degree of uniformity of particle characteristics has not yet been achieved.

In an endeavour to avoid some drawbacks of previous methods, we have developed a technique of drawing compacts containing parallel iron wires embedded in a copper alloy matrix until the iron wires become invisible filaments and the compacts acquire a high intrinsic coercive force. Values of 300–700 oersteds have been obtained so far. (Patent applications have been filed in Australia and overseas countries in respect of these methods and materials.)

Provided the materials within the compacts and the reducing methods are suitably selected, it is possible to preserve a fair uniformity of the iron cross-sections and spacings until the filaments are a few microns in diameter. Below the limit of optical microscopic resolution, magnetic measurements suggest that the iron filaments are excellently aligned and that some of them satisfy the theoretical requirements even when their estimated equivalent diameter is smaller than 0·1μ.

Fig. 1 shows the median intrinsic coercive forces of the individual filaments at infinite spacing, estimated from magnetic measurements of the best compacts produced so far. These results have been obtained only in very fine brittle wires drawn under conditions of extreme cold work and then annealed. More ductile compacts, allowing further reductions, have generally produced lower

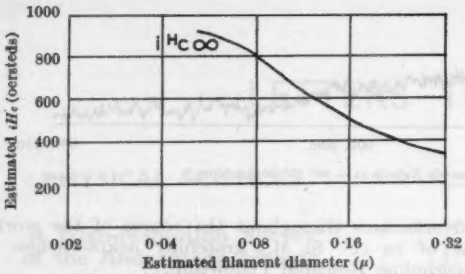

Fig. 1. Estimated median intrinsic coercive force of the individual filaments at infinite spacing versus estimated filament cross-sectional diameter

coercive forces at any given estimated equivalent filament diameter.

Members of the staff of the Division of Tribophysics of the Commonwealth Scientific and Industrial Research Organization have greatly contributed to the success of this preliminary investigation. Thanks are also due to the British Iron and Steel Research Association for supplying a sample of very pure iron wire.

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Sintering of Quartz Crystal

The transformation of quartz into cristobalite at temperatures higher than 1,470° C. has hitherto been accepted as a direct process. Recent measurements of the kinetics of this reaction (unpublished work) have, however, shown that the process is indirect and consists of two consecutive reactions in which a non-crystalline, disordered silica phase appears as an unstable intermediary between the quartz and the cristobalite.

During this work, quartz particles heated at 1,500–1,570° C. were observed to sinter in the early stages of the reaction so strongly as to convert the original loose powder to a hard mass and to reduce the rate of reaction substantially. This effect occurred before any cristobalite had developed and ceased once cristobalite became abundant, when the mass reverted to powder. The purity of the quartz used (Brazilian crystal) ruled out the possibility of any fluid phase except from the quartz itself. It therefore seemed likely that the intermediate non-crystalline phase was responsible for the sintering.

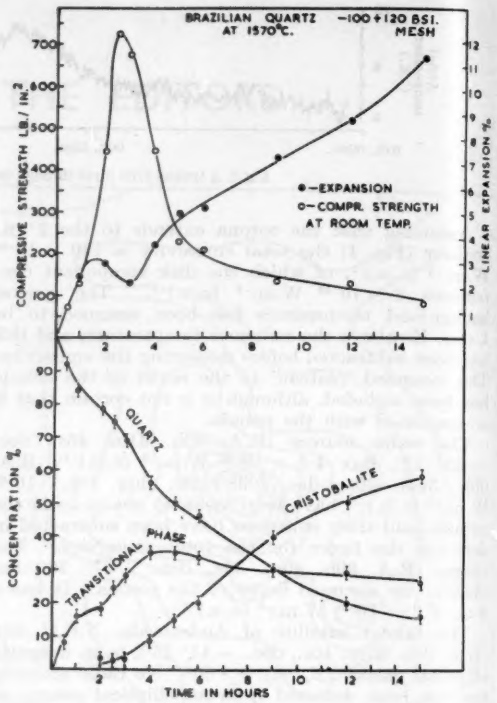

Fig. 1

These effects were studied further by measuring the compressive strength and the linear expansion or contraction, both at room temperature, of pressed cylindrical specimens after firing for various periods at 1,500°, 1,530° and 1,570° C. The results for Brazilian quartz crystal (average diameter 0·137 mm.) at 1,570° C. are shown in Fig. 1. The mineralogical constitution of each sample was determined by differential thermal analysis, which is now established as a reliable method for this purpose[1].

It will be seen that, in the early stages of the reaction, the quartz was transformed solely into the intermediate phase; at the same time, the compressive strength rose rapidly and shrinkage took place. Following the appearance of appreciable

Fig. 2. (a) Ordinary light; (b) partially polarized light; (c) polarized light. (× 200)

amounts of cristobalite (namely, after 3–4 hr.), the strength diminished rapidly; expansion again occurred as the result of the continued conversion of quartz into forms of lower density.

Sintering and shrinkage of pure oxides at high temperatures are usually attributed to diffusion and the formation of 'necks' or lenses at points of contact between the particles. Examination of the quartz under the microscope showed that this mechanism was operative. Fig. 2 illustrates typical examples of the abundant neck-growth found after firing for 2½ hr., when about 20 per cent of the intermediate phase and virtually no cristobalite had developed. Fig. 2*a* is in ordinary light; Figs. 2*b* and 2*c*, in polarized light with partial and total extinction respectively, clearly indicate the intermediate phase as a continuous isotropic layer surrounding the residue of the quartz crystal and forming the neck between the particles. Sintering in quartz thus appears to take place via the disordered surface layer developed at high temperatures and is not inherent in the crystal. The rapid drop in strength on continued heating suggests that cristobalite is similarly deficient in sintering characteristics at the temperatures used. Full details of this work will be published shortly.

This work is part of a programme made possible by the award of an 1851 Senior Studentship to one of us (A. C. D. C.), and we thank the Royal Commission for its support.

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CHEMISTRY

Ionization Potentials of Electron Donors

Recently, Briegleb and Czekalla[1] have described a method of determining the ionization potentials (I_p) of electron donors from the frequencies (ν) of the charge-transfer bands of the complexes of these donors with certain electron acceptors. This is based on a non-linear theoretical relationship between I_p and ν.

Similar results may be obtained from an empirical linear relationship between I_p and ν; this is sufficient to correlate the experimental values of I_p and ν. Such relationships have been determined for complexes of donors of reliably known ionization potential[2] (namely, benzene, toluene, *m*-xylene, mesitylene, naphthalene, 1-methylnaphthalene and aniline) with the electron acceptors chloranil (C), *p*-benzoquinone (Q) and 1,3,5-trinitrobenzene (T) respectively. These are:

$$I_p = 5{\cdot}13 + 1{\cdot}39 \times 10^{-4}\,\nu_C$$
$$I_p = 4{\cdot}61 + 1{\cdot}33 \times 10^{-4}\,\nu_Q$$
$$I_p = 4{\cdot}25 + 1{\cdot}39 \times 10^{-4}\,\nu_T$$

for solutions in carbon tetrachloride, where I_p is in electron volts, ν in cm.$^{-1}$, and the subscripts to ν indicate the appropriate electron acceptor.

From measurements of frequencies of charge-transfer bands of complexes of these three acceptors with other donors in carbon tetrachloride, the ionization potentials may be evaluated. Examples are quoted in Table 1.

Table 1

Donor	Ionization potential (eV.)				
	Calc. from ν_C	Calc. from ν_Q	Calc. from ν_T	Mean	Ref. 1
Durene	8·0	8·2	8·3	8·2	8·4
Pentamethylbenzene	7·9	7·9	7·9	7·9	—
Hexamethylbenzene	7·8	7·8	7·8	7·8	7·9
Anthracene	7·4	7·4	7·4	7·4	7·4
N,N-Dimethylaniline	7·3	7·3	7·1	7·2	—
N,N,N′,N′-Tetramethyl-*p*-*p*′-diaminodiphenylmethane	7·1	7·0	7·1	7·1	—
N,N,N′,N′-Tetramethyl-*p*-phenylenediamine	6·7	6·7	6·7	6·7	—

For aromatic electron donor molecules, save those of very low ionization potential where it is improbable that such relationships are justified, this method may provide a simple means of estimating ionization potentials which may be difficult to determine by other methods, such as Rydberg series, photoionization and electron impact, because of practical details such as the low vapour pressure of some of these substances.

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[1] Briegleb, G., and Czekalla, J., *Z. Elektrochem.*, **63**, 6 (1959).
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Radioassay of Aqueous Solutions mixed with Solid Crystalline Fluors

I have previously described a new approach to direct radioassay of aqueous solutions of weak beta-ray emitting isotopes in the liquid scintillation spectrometer[1]. The aqueous solution was intimately mixed with a mass of finely divided beads of clear plastic into which a fluor (diphenylstilbene) has been incorporated (Pilot *B*-Beads, Pilot Chemicals, Inc., Watertown, Mass.). We wish to report that a number of crystalline fluors, more efficient, less expensive and more generally available, can be substituted for the plastic and used in an analogous fashion despite their poorer light-transmitting qualities[2]. For example, in a slurry made up of 0·7 ml. $Na_2{}^{14}CO_3$ and 0·5 gm. diphenyloxazole the carbon-14 was counted with 27 per cent efficiency. Instead of trying to hold the solid fluor in stable suspension, which can be done with the help of thickeners such as glycerol, it has proved more satisfactory to let the fluor settle to the bottom of the vial. Addition of a detergent is essential to ensure prompt and uniform wetting of the crystals. The performance of a fluor depends not only on its inherent fluorescence efficiency but also on the size and shape of the crystals, since the closeness of packing determines the mean free path of beta-particles through the solution before they encounter a fluor crystal. Best results thus far have been obtained using blue-violet fluorescence-grade anthracene crystals (Distillation Products Industries, Rochester, N.Y.). This highly purified material was three times as efficient as ordinary 'chemically pure' anthracene. The difference may in part reflect the presence of trace impurities in the latter, known to

shift the fluorescence to higher wave-lengths. Even different lots of fluorescence-grade anthracene may differ by 20–30 per cent in efficiency, but the material in any given lot gave excellent reproducibility without further treatment. A routine technique currently used in our laboratories for carbon-14 and tritium is described.

Exactly 1 gm. of anthracene is weighed into a 5-dram counting bottle (T. C. Wheaton Co., Millville, N.J.), 3 ml. of the unknown solution (containing 1 : 1,000 'Triton *GR-5*', Rhom and Haas Co., Philadelphia, Pa.) is pipetted on to the mass of anthracene and the mixture is stirred, breaking up any clumps of crystals. After an hour to allow the crystals to settle completely, the vial is ready for counting. The count-rate does not appear to be sensitive to temperature in the range 0–25° C., but freezing can alter the count-rate, depending on the extent to which radioactive solute becomes concentrated adjacent to the crystals during freezing. Counting in the present study was done in the Packard liquid scintillation spectrometer with a box temperature of approximately 2° C., photomultiplier voltage 1,345 V. (tap 10) and 'window' setting 10–∞. Under these conditions absolute efficiency for carbon-14 in 3 ml. of solution is 20 per cent; for tritium, 0·5 per cent. Background-rate is 90–110 c.p.m. At 1,200 V. background is only 65 c.p.m. and efficiency is only 10 per cent less than it is at 1,345 V.

As shown in Fig. 1 smaller volumes added to the 1 gm. of anthracene are counted with considerably higher efficiency (maximum of 54 per cent for carbon-14, 2·3 per cent for tritium when only the crystals at the top are wetted) but reproducibility is less satisfactory and quenching correction with internal standard cannot be easily made. Above 3 ml. sample volume, further addition of a sample of the same specific radioactivity in c.p.m./ml. does not further increase the observed count-rate. Reproducibility of the routine method is shown by replicate analyses of an aqueous solution of alanine-1-^{14}C, which gave standard deviations of 3·6 per cent (7 samples) and 4·1 per cent (5 samples). Three sets of four replicate samples of tritiated water were counted with a maximum range of ± 3·5 per cent. Quenching due to materials with absorption spectra overlapping the emission spectrum of anthracene is corrected for by adding an internal standard of the appropriate isotope in a volume of 0·05 ml., stirring and recounting. The validity of such a quenching correction is shown by the results in Fig. 2.

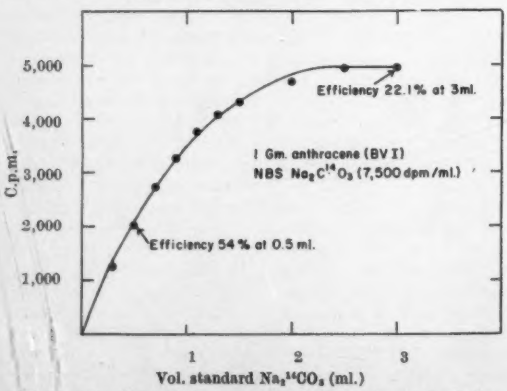

Fig. 1. Counting efficiency as a function of volume of solution added to a fixed amount of anthracene

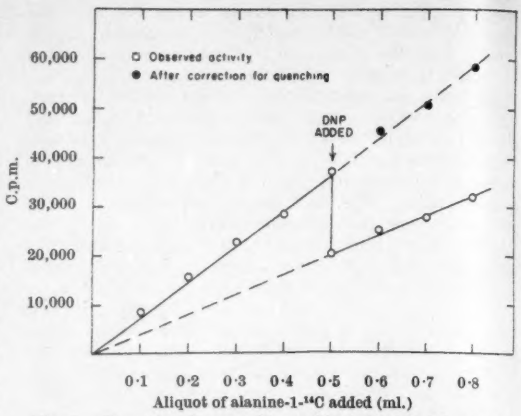

Fig. 2. Correction for quenching. The indicated aliquots of alanine-1-^{14}C were added to a vial containing 1 gm. of anthracene and 12 ml. of water containing 1 : 1,000 'Triton'. 2,4-Dinitrophenol was added at the point indicated

The method has been successfully applied to solutions of proteins, glucose, amino-acids and sodium carbonate in water or in buffer and to proteins and sodium carbonate in sodium hydroxide. It should be applicable to any material soluble in aqueous solvents and not reacting with anthracene. It has been shown that small molecules such as sodium carbonate, glucose and amino-acids can be quantitatively recovered by washing the anthracene. This feature of the method may be particularly valuable when only small amounts of sample are available and a radioassay is desired prior to further studies. Another important application of the method is in the counting of material of low specific activity when large amounts are available. If the material does not quench the fluorescence, it may be concentrated to high levels so that many milligrams are counted at the indicated efficiency. Larger amounts of anthracene have also been used (for example, 12 ml. of solution with 6 gm. anthracene) and even though the efficiency does not go up linearly (a large fraction of the emitted light comes from the upper surface of the anthracene mass) this permits considerably higher absolute count-rates. It may make feasible the counting of polar compounds with specific radioactivity too low to count in the conventional liquid scintillation systems, considering the limitations in sizes of sample sometimes involved.

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[1] Steinberg, D., *Nature*, **182**, 740 (1958).
[2] Presented in part at Symposium on Advances in Tracer Applications of Tritium, October 31, 1958, New York City.

Derivatographic Investigation of the Anthracite of the Don

The anthracite of the Don has been investigated by the derivatographic method of F. Paulik, J. Paulik and L. Erdey[1]. By this method it is possible, by a single, automatically recorded measuring process, to obtain not only the thermogravimetric curve showing the change in weight of the sample (*TG* in Fig. 1) but also the rate of loss of weight (*DTG*) and

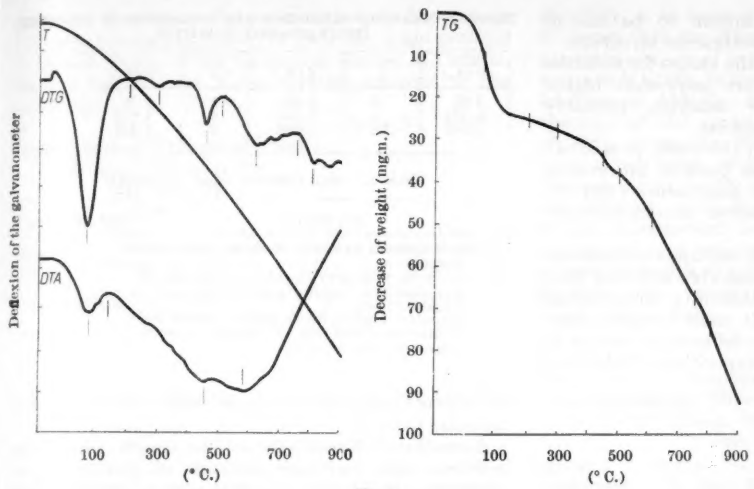

Fig. 1

the differential thermal analysis curve (*DTA*), giving information on the changes in temperature during thermal decomposition. The temperature curve (*T*), with the assistance of a calibration curve previously photographed on the paper, gives the temperature corresponding to each point obtained.

The immediate analysis of Don anthracite is as follows: ash, 9·4 per cent; combustibles, 90·6 per cent; coke, 96·3 per cent; carbon fix, 86·9 per cent; volatiles, 3·7 per cent.

By adjusting the sensibility of the balance, its full-scale deflexion was made to correspond to a change of weight of 100 mgm. A rate of heating of 5 deg. C./min. was maintained from room temperature to 900° C. Experiments were carried out in a stream of nitrogen (15 l./hr.).

The maximum rate of release of water vapour from the sample (water content, 2·5 per cent) occurs at 80° C. An endothermic maximum on the *DTA* curve occurring at 85° C. corresponds to this peak in the release of water. As only a relatively small part of the water is driven off in the temperature-range above 100° C., it appears that water is bound mainly by absorptive forces in the anthracite, chemical forces playing a relatively insignificant part.

A small peak occurs on the *DTG* curve at 295° C. This peak is of great interest, as it shows that atomic groups and structures characteristic of cellulose and plant residues are still conserved—though to a small degree—in anthracite.

In the derivative thermogravimetric study of peats and peat constituents[2], a high peak was reported at 300° C. in the thermal decomposition of cotton cellulose. When projecting the data of the *DTG* curve on the *TG* curve, it can be seen that this characteristic cellulose structure is present in only 0·3 weight per cent in anthracite, presumably in the form of side-chains.

The decomposition peak at 350° C., characteristic of humic acids, does not appear at all on the *DTG* curve of the anthracite.

The next peak of the *DTG* curve occurs at 450° C. This maximum is analogous to the main peak in the decomposition of bituminous coals, the position of which was found to vary between 390° C. and 420° C., according to the quality of the bituminous coal. As the temperature of decomposition is a function of the rank of coal, and the peak of decomposition is shifted towards higher temperatures with higher ranks of coal, it is not unexpected that in the case of anthracite—the last of the series—it should occur at 450° C.

It was found in an earlier investigation, by comparing the results of derivatographic analysis with those of dilatometric tests, that the main peak on the decomposition curve corresponds to the resolidification temperature T_s, that is, to the beginning of coke formation. Although anthracite does not pass into the plastic state through the action of heat, and consequently no resolidification takes place, it can reasonably be supposed, on the analogy of bituminous coals, that the peak exhibited by anthracite at 450° C. also marks the initial temperature of coke formation.

These observations are in good agreement with the X-ray results reported by Lermusiaux and Quinot[3]. They conclude from the radiograph of anthracite that the structure of anthracite contains particles of 5·7 A. radius, consisting of 84 carbon atoms, which are distributed in two layers, spaced at 3·4 A. from one another. The individual particles are linked together by oxygen-bridges.

The evolution of gases, consisting chiefly of carbon monoxide and carbon dioxide, in the temperature range 200–500° C. can be attributed to the rupture of these oxygen bridges. Above 500° C. a substantial change occurs in the radiograph. A structure of 12 carbon atoms characteristic of coke appears. The particles consist of two graphite hexagons, 3·4 A. apart; whereas in coke from bituminous coals the particles are strongly linked by carbon atoms and radicals formed of cracked bitumen, the hexagons in coke from anthracite are not linked together materially.

My derivatographic investigations suggest that coke formation begins at 450° C. This result agrees well with the X-ray results mentioned above, as it is obvious that coke formation must have progressed to a certain degree before the coke structure becomes observable radiographically. Above 500° C. the character of the evolved gases also changes, and the gases released consist chiefly of hydrogen. The appearance of hydrogen may be ascribed to the depolymerization of the 84 carbon-atom structure and the formation of the 12-carbon graphite hexagons:

$$C_{84} \rightarrow 7\,C_{12}$$

The *DTG* and *TG* curves suggest that the structure characteristic of bituminous coals contributes only 0·7 per cent to that of the anthracite, but as it is split off in a relatively limited temperature interval of not more than 100 deg. C., it is easily observable.

The most important quantitative changes in anthracite occur above 500° C. The loss of weight in the range 500–800° C. amounts to 3·5 per cent. The changes in this region, which exhibits a

further peak above 600° C., appear to be due to strong depolarization of the anthracite structure.

It should be mentioned that the values for volatiles obtained derivatographically are somewhat higher than those from immediate analysis, probably because of the slower rate of heating.

The *DTA* curves show that the peak at 450° C. analogous to the decomposition peak of bituminous coals, and the decomposition peak above 500° C. characteristic of depolymerization are both endothermic.

Derivatographic results with anthracites from another source may possibly be somewhat different from those obtained for the Don anthracite; nevertheless, since the structure of different coals becomes more similar with higher rank, great differences are not to be expected in the thermal decomposition of individual anthracites.

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MINERALOGY

Variation in Etch Behaviour of Jacobsite with Different Cell Dimensions

During the study of polished sections of manganese ores from the Kodur Group of mines, Srikakulam Dt., Andhra Pradesh, India, I came across three different types of jacobsite, associated with other manganese minerals like braunite, hausmannite, pyrolusite, cryptomelane, coronadite and γ-MnO_2. It is the interesting variation in the colour and etch behaviour in the different types of jacobsite that attracted my attention, and investigations to find out the cause of such variation were attempted.

Of the three different types of jacobsite, one occurs as a homogeneous mineral, pseudomorphous after garnet, whereas the other two types are in widmanstatten intergrowth with hausmannite. Of the last two types, one exhibits all the characters of normal jacobsite as described by Ramdohr[1] and Uytenbogaardt[2]. It is non-pleochroic olive-grey in colour with reflecting power of 19·6 per cent in green light in air, isotropic and negative to all standard reagents. It is the second type of jacobsite in intergrowth with hausmannite that exhibits altogether different colour under reflected light, and its reactions to etch reagents are also different. It is rose-brown in colour with reflecting power of 20·01 per cent in green light in air. It reacts with concentrated hydrochloric acid in 1½ min. and the solution turns greenish-yellow. With hydrofluoric acid, the mineral is instantaneously etched black with corroded surface; the etching is much faster than in the hausmannite exsolution lamellæ. All these characters are very similar to those exhibited by magnetite, though the mineral was conclusively identified as jacobsite by X-ray powder analysis (Table 1). All the different types of jacobsite yielded similar *d* spacings, though their other characters vary considerably.

To investigate the possible cause of this peculiar etch behaviour of jacobsite, the cell dimension of all the three types was measured and the results are given in Table 2.

Table 1. Measured *d* Spacings and Intensities of Jacobsite. Iron/Manganese Radiation

d (A.)	*I*	*d* (A.)	*I*	*d* (A.)	*I*
4·86	4	2·42	1	1·72	2
2·975	4	2·105	4	1·619	5
2·542	10	2·024	2	1·489	7

Table 2. Cell Dimensions of Jacobsites

Description	Cell dimension
1. Homogeneous jacobsite pseudomorphous after garnet	a = 8·506 A.
2. Jacobsite, olive-grey in colour, unetched by any standard reagent, in intergrowth with hausmannite	a = 8·483 A.
3. Jacobsite, rose-brown in colour, etched by hydrochloric acid and hydrofluoric acid, in intergrowth with hausmannite	a = 8·410 A.

According to Mason[3], the cell dimension of jacobsite increases with increased amounts of manganese in structure. In Table 2, the first type of jacobsite has the largest cell dimension (a = 8·506 A.), which, according to Mason's[3] diagram (p. 146), contains a fair amount of manganese in excess of minimum. This excess manganese could not exsolve, apparently due to lack of proper temperature. The second type of jacobsite has all the characters of true jacobsite, and its cell dimension compares favourably with any normal jacobsite in the vredenburgite field. The third type has a much smaller cell dimension (a = 8·410 A.), which indicates, according to the experiments of Mason[3], that it approaches the magnetite–jacobsite transition field with about the minimum quantity of manganese in solid solution. It may thus be concluded that, while the mineral has just the structure of jacobsite, the composition tends more to that of magnetite and therefore its reactions to etch reagents conform more to magnetite than to jacobsite. This type of jacobsite with composition approaching the magnetite–jacobsite transition field, and exhibiting corresponding etch behaviour, should not be too uncommon in the metamorphic manganese ores of India, of which jacobsite is an important constituent. It may be that such etch characters were overlooked in earlier investigations.

I acknowledge the facilities I enjoyed in the laboratories of the Department of Geological Sciences,

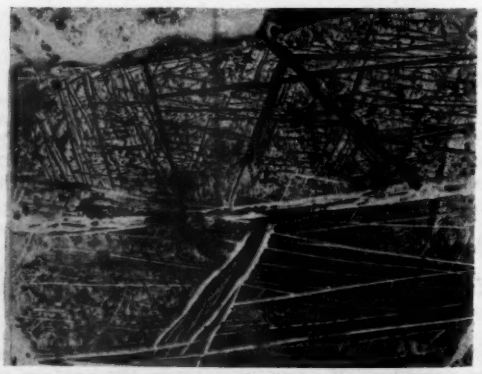

Fig. 1. Etch behaviour of jacobsite. A single grain of vredenburgite etched with hydrofluoric acid (bottom portion) and stannous chloride (top portion). Hydrofluoric acid etches jacobsite sooty black but hausmannite is unaffected. Stannous chloride etches hausmannite but did not attack jacobsite. (× 200)

Jadavpur University, Calcutta, and of the Mineralogy Division, Geological Survey of Canada. I am grateful to Miss J. Trask, of the Geological Survey of Canada, for her help in the X-ray powder analysis of the jacobsites.

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The Spinel–Olivine Inversion in Mg_2GeO_4

DURING the past few years there has been active interest in the problem of alternative explanations other than layers of different composition in the Earth to explain seismic data. The most important of these arises from an early suggestion by Bernal[1] regarding the possible inversion of the orthorhombic mineral olivine to a dense form with the spinel structure. An actual example of this inversion from the spinel to the olivine had been reported by Goldschmidt[2] for the compound Mg_2GeO_4. However, there have always been some doubts regarding this observation, since it was mentioned only in a footnote and could not be repeated.

With the revived interest, there have apparently been several attempts[3] to synthesize the spinel form of Mg_2GeO_4. But the general conclusion was that this form probably does not exist. However, in 1954, Roy and Roy[4] reported the reproducible synthesis and reversible inversion to olivine of a spinel form of Mg_2GeO_4. This work has been generally missed, since the paper describing it was concerned with the morphology of synthetic serpentines. In 1955, a quantitative equilibrium study of the whole problem was started with the view of determining the pressure–temperature conditions for the inversion of natural olivines into spinel structures. The problem was tackled in stages by determining a series of t–x sections of the Mg_2SiO_4–Mg_2GeO_4 system; the study of t–x sections with 10 and 20 mol. per cent Fe^{3+} replacing Mg^{2+}, and finally a p–x section of the Mg_2GeO_4–Mg_2SiO_4 system at 542° C. up to the experimental limit of 65,000 atm. Many of these results were presented orally at the 1956 annual meeting of the Geological Society of America[5]. While the results of this extensive experimental study will be published later elsewhere, it is considered worth while to summarize here the new data on the spinel–olivine inversion obtained from some four hundred runs in hydrostatic or uniaxial pressure devices.

The work utilized high-pressure water as a catalyst, and under such conditions there is no problem with reproducible synthesis of the spinel phase. The inversion temperature for the Mg_2GeO_4 (spinel) $\rightleftarrows$ Mg_2GeO_4 (olivine) equilibrium (obtained by extrapolation from runs as low as 1,000 lb./sq. in.) is 810° C. at atmospheric pressure. The ΔV of inversion from X-ray data is 3·5 cm.³/mol.; ΔH (calculated from the pressure-dependence slope) is 3,690 cal./mol. The entropy of inversion is thus a reasonable 3·4 E.U. The inversion temperature is raised by 0·025 deg. C./bar for the first 5,500 bars. X-ray intensities and infra-red absorption spectra clearly show that Mg_2GeO_4 is an inverse spinel. It may be of interest to record that the inversion in Mg_2SiO_4 as determined by extrapolation of experimental points up to 60 mol. per cent Mg_2SiO_4 in the p–x section is set at 100 ± 15 kilobars at 542° C. Further, the change in lattice spacings of the spinel solid solutions of Mg_2GeO_4·Mg_2SiO_4 shows that the spinel form of Mg_2SiO_4 will have a cell edge of 8·22 A. Therefore, the ΔV of this transition is 2·0 cm.³/mol. The dependence of the Mg_2SiO_4 transition upon pressure is beyond direct experimental study at present, but from a consideration of various sections in the p–t–x volume constructed with the data for the system Mg_2GeO_4–Mg_2SiO_4, one would expect that it will be only 0·013 deg. C./bar.

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BIOCHEMISTRY

Chlorination of Proteins as a Method of increasing their Opacity in the Electron Microscope

THE basic difficulty in devising a method for selectively increasing the density of protein in a tissue section, in order to increase its contrast under the electron microscope, is to choose some atom or group of atoms unique to the protein, and which may be replaced or substituted by some heavier atom or group. The amide group occurs in all proteins as the peptide link, while it is absent in all other macromolecular cell constituents. N-chlorination(·NH·CO·→ ·NCl·CO·) is a well-known reaction with simple amides, and it therefore seemed that chlorination might offer a simple means of increasing the density of the protein. Although chlorination of other cell constituents (and other structures in the protein) would undoubtedly also occur, it was considered that the background increase in density produced in this way would be small compared with the increase in density of the protein, for theoretically 1 gm. atom of chlorine can react with each 100–150 gm. of protein, depending upon its amino-acid composition. Vandevelde[1] has shown that many proteins, both fibrous and globular, react with chlorine to give materials which contain about 15 per cent chlorine, a content which corresponds to substitution at most of the peptide links. Most of the chlorine is lost from the modified protein by treatment with water, giving hydrochloric acid, which probably arises by hydrolysis of the N—Cl bond followed by oxidation of the protein by the hypochlorous acid which is formed. Exposure to chlorine gas, followed by spraying with iodine and starch solutions, has been used as a delicate test for amino-acid, peptide and protein spots on paper chromatograms[2].

Table 1. Chlorination of Various Proteins by *tert.* Butylhypochlorite ($(CH_3)_3 \cdot C \cdot OCl$) in Anhydrous Petroleum Ether

Protein	Gm. protein per gm. atom of chlorine absorbed		
	20 hr.	60 hr.	160 hr.
Native albumin	12,500	4,460	1,057
Alcohol denatured albumin	*538*	*223*	*132*
Fibrin	106	102	100
Keratin	3,570	777	509

We have studied the uptake of chlorine by several dried proteins, suspended in anhydrous solutions of chlorine or *tert.* butylhypochlorite[2] in inert solvents, by estimating the excess active chlorine by iodometry after a given time. The results of a typical experiment are shown in Table 1.

Similar results were obtained with chlorine in dry carbon tetrachloride; in a number of cases estimation of the chlorine content of the modified protein by the Carius method showed that these figures were essentially correct. Denatured albumin, like the fibrous protein, fibrin, reacted much faster than native albumin, presumably because the disordered peptide chains were more freely accessible to the chlorinating agent. Keratin, in which the structure is additionally stabilized by disulphide cross-links, showed an intermediate reactivity.

In order to test whether a useful increase in contrast under the electron microscope would be observed in protein treated in this way, horse red blood cell erythrocytes were suitable as test objects because they consist largely of protein and are not completely opaque to electrons with accelerating potentials of the order of 75 kV. A bulk preparation of erythrocytes was made by the method of Hillier and Hoffman[4], and after denaturation with alcohol and thorough drying, this material was chlorinated (chlorine in carbon tetrachloride for 24 hr.). The treated erythrocytes contained 11·2 per cent chlorine, and titration of the excess chlorinating agent gave a figure of 206 gm./gm. atom of chlorine absorbed. For electron microscopy, the erythrocytes were deposited directly on an evaporated carbon film mounted on a copper grid, by allowing a small drop of dilute aqueous suspension to evaporate. After immersion in alcohol for several hours, the grids were dried for several days over calcium chloride before they were exposed to dry chlorine gas for 24 hr. Many experiments of this type were made, and under the interference microscope the erythrocytes appeared largely undamaged, provided anhydrous conditions were rigorously maintained. However, under the electron microscope, at a magnification of 10,000–20,000, it was never possible to find a specimen in which the fine structure was not badly disrupted. Frequently a twisted mass of filaments and spirals was observed, and it was consequently impossible to obtain reliable density measurements.

Hydrogen-bonding through the >NH group must necessarily be destroyed by chlorination at the peptide link, and it is this bonding which is thought to be important in maintaining the precise geometry of the folded peptide chains. It is considered that the type of damage observed, together with the rates and extent of chlorine uptake by different types of proteins, is consistent with the view that chlorination at the peptide link occurs with breakdown of hydrogen-bonding between individual amino-acids in the peptide chains, and between peptide chains. If this view is correct, other methods of substitution at the peptide link would also lead to destruction of the protein ultrastructure.

We are indebted to Prof. J. T. Randall and Dr. S. Fritton-Jackson of the Wheatstone Physics Laboratory, King's College, who carried out the electron microscopy. One of us (M. M. C.) wishes to thank the Nuffield Foundation for a research fellowship, during the tenure of which this work was carried out.

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Glucose-*cyclo*-Acetoacetate as a Precursor of Ascorbic Acid in Germinating Green Gram

That glucose-*cyclo*-acetoacetate acts as a precursor of ascorbic acid in germinating green gram or mung beans (*Phaseolus radiatus*) has been shown by Nath and his associates[1–3] and confirmed by the use of labelled glucose-*cyclo*-acetoacetate by Thangamani and Sarma[4]. Neither the titrometric indophenol dye method of Bessey and King[5] nor the colorimetric method of Roe and Kuether[6] is specific for L-ascorbic acid. We have therefore used paper chromatography to identify the additional reducing substance formed from glucose-*cyclo*-acetoacetate during the process of germination which decolorizes the indophenol dye, and find it to be L-ascorbic acid.

If glucose-*cyclo*-acetoacetate were a true precursor of ascorbic acid in such a process, the chromatograph would be expected to show greater biosynthesis of ascorbic acid (as indicated by a specific R_F value) on the addition of glucose-*cyclo*-acetoacetate in the germinating medium. The amount of ascorbic acid formed would also be expected to be directly proportional to the amount of glucose-*cyclo*-acetoacetate added.

We adopted the technique of circular paper chromatography used by Nath and Bhattathiry[7] to identify another dienol compound (1 : 2 dienol glucose) in normal blood, and silver nitrate–ammonia was used for staining the chromatogram, as used by Partridge[8] for ascorbic acid.

Chromatograms with a standard ascorbic acid solution and deproteinized extracts of the same weight of seeds germinated for 72 hr. in (*a*) water and (*b*) aqueous solutions of glucose-*cyclo*-acetoacetate, using either 50 mgm./100 seeds or 100 mgm./100 seeds, were obtained. Whatman filter paper No. 1 of 28 cm. diameter fitted with a wick at the central hole was employed, in a Petri dish placed in a closed chamber with a solvent mixture consisting of butanol/acetic acid/water (40 : 10 : 50), the top layer being used. The paper was allowed to dry in air and the staining was done by spraying with a cold solution of silver nitrate–ammonia.

It will be evident from the bands in the chromatogram (Fig. 1) that all of them have the same R_F value, namely, 0·52, which was found to be specific for ascorbic acid by Nath and Bhattathiry[7]. The intensity of the colour of the (G_2) bands with 100 mgm. glucose-*cyclo*-acetoacetate/100 seeds is much greater than that of the (G_1) band with

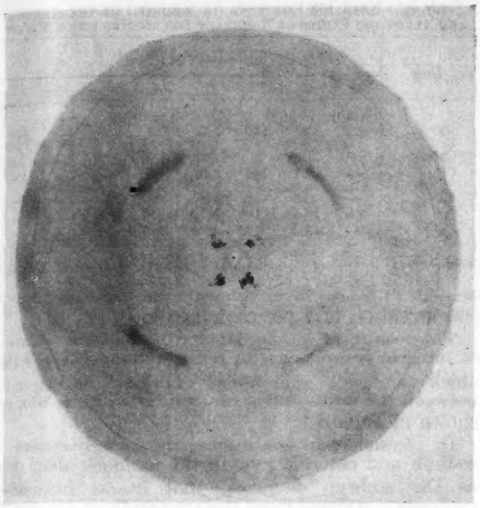

Fig. 1. Circular paper chromatogram showing: *St*, standard ascorbic acid solution; *SW*, aqueous extracts of seeds germinated in water alone; G_1 and G_2, aqueous extracts of seeds germinated with glucose-*cyclo*-acetoacetate (50 mgm. and 100 mgm./100 seeds respectively)

50 mgm. glucose-*cyclo*-acetoacetate/100 seeds, which is again much greater than that (*SW*) with seeds germinated in water only. This confirms that the reducing substance formed from glucose-*cyclo*-acetoacetate during the process of germination of mung beans is ascorbic acid and its biosynthesis varies directly with the amount of glucose-*cyclo*-acetoacetate added.

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PHYSIOLOGY

Antagonism of Choline and Inositol

Simultaneous administration of choline and inositol to rats prevents the formation of fatty liver to a greater extent than if either substance were given alone[1]. There have also been several isolated reports which suggest to us the existence of an antagonism between choline and inositol. Suppression by choline of the growth of yeast requiring inositol has been reported by Taylor and McKibbin[2]. The addition of choline depressed growth under conditions in which growth was limited by the concentration of inositol in the incubation medium. Also, in studies of renal necrosis found in developing rats fed a diet deficient in choline, Handler[3] observed that the addition of inositol to that diet greatly aggravated the renal necrosis, while it reduced the degree of liver fat in the same animals.

In a study of perosis (slipped tendon) of the developing turkey fed a diet deficient in choline, Jukes[4] observed that dietary inositol cannot relieve the perosis and may even accelerate its appearance. The experiments reported here establish that the addition of inositol to the diet of chicks deficient in choline causes a marked aggravation of perosis, both in rate of appearance and in degree, and that the degree of perosis is intensified by increasing the amount of added dietary inositol (Table 1).

Table 1. Effect of Inositol upon Perosis and Growth of Choline-deficient Chicks

Diet	Average perosis score per chick		Average body-weight ± S.E. (gm.)	
Added inositol (per cent)	After 2 weeks	After 4 weeks	After 2 weeks	After 4 weeks
0	0·25	2·75	110 ± 3	263 ± 10
0·2	0·88	3·68	116 ± 4	244 ± 19
1·0	1·8	4·5	108 ± 7	224 ± 27

Eight New Hampshire chicks, one day old, were placed on each diet (Table 1) *ad libitum* for four weeks. The basal diet consisted of 'Drackett *C*1' soy protein, 300 gm.; L-cystine, 3 gm.; corn oil, 40 gm.; salts *A*, 60 gm.; crude glucose, 597 gm.; thiamine hydrochloride, 8 mgm.; riboflavin, 8 mgm.; calcium pantothenate, 20 mgm.; nicotinic acid, 100 mgm.; pyridoxine hydrochloride, 8 mgm.; D-biotin, 0·3 mgm.; pteroyl glutamic acid, 3 mgm.; vitamin B_{12}, 0·1 mgm.; vitamin A acetate, 6 mgm.; α-tocopherol, 25 mgm.; α-tocopherol acetate, 25 mgm.; vitamin D_3, 0·02 mgm.; 2-methyl-1,4-naphthoquinone, 1 mgm. The degree of perosis was graded from zero to three by the gross appearance of each leg: maximum severity, designated by a score of 3 for each leg, representing complete loss of the use of the leg.

While the mechanism of the lipotropic action of inositol and choline *in vivo* is still unknown, it is of interest that recent experiments on the biosynthesis of lipids indicate the presence of common intermediates which participate in the formation of inositol- and choline-phosphatides as well as triglycerides[5,6]:

L-α-glycerophosphate
↓ 2 *RCO*-CoA
L-α-phosphatidic acid —(cytidine nucleotide)→ inositol-phosphatide
↓ (inositol)
D-α,β-diglyceride —(*CDP*-choline)→ lecithin
↓ *RCO*-CoA
triglyceride

This scheme suggests that either choline or inositol might exert a lipotropic effect by stimulating formation of the corresponding phosphatide, in which form fatty acids are perhaps more soluble or are otherwise made more accessible to further metabolism than they are in the form of triglycerides.

On the other hand, during periods of rapid synthesis of cells, such as the growth of a young animal, it is likely that specific phosphatides are required for the formation of cellular and subcellular constituents and that for this purpose inositol and choline are not interchangeable.

Thus there is evidence suggesting synergism between inositol and choline from experiments

related to lipotropic action, and there is also evidence of antagonism in experiments related to growth. This paradox may be explained by present knowledge at the enzyme-level. The synergistic lipotropic action may be related to a shunt of precursors away from triglyceride formation by either inositol or choline, while the antagonism may be related to depression of the formation of a particular structural phosphatide by the precursor of another, for example, lecithin, by inositol under conditions in which low levels of choline are present.

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Sodium, Potassium, Calcium and Chloride Ion Contents and Protein Fractions in the Fluids of Chick Embryos

Among substances present in the amniotic fluid, the protein fractions and mineral components preserving osmotic equilibrium between the amnion and the growing embryo itself are especially significant for the development of the embryo.

In the present investigation, the amniotic fluid from incubated hen's eggs was used and for comparison the allantoic fluid and the rest protein of fertile eggs between the tenth and seventeenth days of incubation. For this purpose, a culture of embryos was grown at the Institute of Medical Microbiology of the Medical Academy at Poznań. The amniotic and allantoic fluids were extracted with an aseptic needle and syringe after breaking the egg shell, and were transferred to corked aseptic tubes. Protein from incubated eggs was placed in weighed test-tubes containing a physiological salt solution or buffer solution necessary for electrophoretical investigations. The fluids and protein were kept in a refrigerator until used in experiments.

The level of sodium, potassium and calcium ions in the amniotic and allantoic fluids was determined with a flame photometer (Zeiss, Jena), and their contents expressed in milliequivalents. The chloride ion content was determined by Volhard's method and also expressed in milliequivalents. The total protein content was examined by the biuret method[1], using a Coleman spectrophotometer. The protein fractions of both fluids and the rest protein were separated by free electrophoresis ('Fokal' *F* apparatus, constructed according to Arne Tiselius by Strübin, Basle). For obtaining protein diagrams the following buffer solution was used: veronal sodium salt, 5·88 gm.; sodium acetate ($CH_3COONa.3H_2O$), 3·88 gm.; potassium oxalate ($(COOK)_2.2H_2O$). 1·38 gm.; hydrochloric acid 0·1 *N* (HCl), 20·00 ml.; distilled water to 1 litre. Such a solution has *p*H 8·9, and ionic strength μ 0·1. Before electrophoresis, the amniotic and allantoic fluids of low protein contents were condensed *in vacuo* over phosphorus pentoxide to a concentration of 1 per cent protein.

Table 1. Mean Ion Contents (in m.equiv.) of the Amniotic and Allantoic Fluids of Normally Developing Chick Embryo

Ions	Days of life							
	10	11	12	13	14	15	16	17
	Amniotic fluid							
Na^+	127	134	130	132	112	107	119	118
K^+	4·1	4·5	4·7	7·0	21·8	23·8	19·2	18·0
Ca^{2+}	—	1·6	2·1	3·5	4·7	3·6	—	3·2
Cl^-	—	131	141	144	108	—	—	—
	Allantoic fluid							
Na^+	—	115	110	105	84	82	—	—
K^+	—	12·0	13·0	20·0	25·0	26·0	—	—
Ca^{2+}	—	3·5	2·0	2·4	1·5	2·0	—	—
Cl^-	—	68	90	84	72	—	—	—

The results of measurements of the concentration of mineral components in both fluids of the growing chick embryo, undergoing normal development between the tenth and seventeenth day of its life, are shown in Table 1.

In physiological conditions, the concentrations of sodium and chloride ions in the amniotic fluid drop as the embryo develops, that is, as incubation proceeds; starting from the thirteenth or fourteenth day of the life of the embryo, the level of potassium ion rises to 4–5 times its value in the earlier days. The allantoic fluid was found to undergo analogous changes in ion content; however, the potassium ion has originally a higher concentration here than in the amniotic fluid. The sodium and calcium ions have lower concentrations in the allantoic fluid than in the amniotic fluid.

The present results differ from those of Kamei[2], obtained in 1927, especially with regard to sodium, potassium and calcium ion determinations in both fluids. The fact that Kamei obtained higher values for these ions is probably due to his use of gravimetric methods: sodium and potassium were weighed as chloride, potassium was estimated separately as potassium chloroplatinate (K_2PtCl_6) and the sodium ion level determined by subtraction. Kamei's results for chloride generally coincide with the present results, though they are somewhat higher. It is also possible that the discrepancy arises from some differences in the races of hens used for investigation.

Daily control of the levels of ions made it possible to detect differences in the level of potassium ions between the twelfth, thirteenth and fourteenth days of the embryo in both fluids. This was not noticed by Kamei, whose measurements date from the ninth and fourteenth day.

Simultaneously with the rise in content of potassium ions in the amniotic fluid, the protein content undergoes a marked change on the thirteenth or fourteenth day of the life of the embryo. In fact, determinations of the total protein showed the amniotic fluid to be poor in protein during the eleventh to thirteenth days of embryonic development, when the protein concentration amounts to no more than 0·5 gm. per 100 ml. of the fluid. On the other hand, the amniotic fluid of an embryo more than 14 days old is highly proteinous, containing 9–10 gm. of protein per 100 ml. of the fluid.

The amniotic fluid of low protein content, on being concentrated *in vacuo*, showed three fractions on the electrophoretic diagram. That with the greatest velocity contains about 98 per cent of the total amount of protein, the two remaining fractions containing but 1 per cent each (Fig. 1*a*). Allantoic fluid of low protein content exhibited a similar electrophoretic diagram.

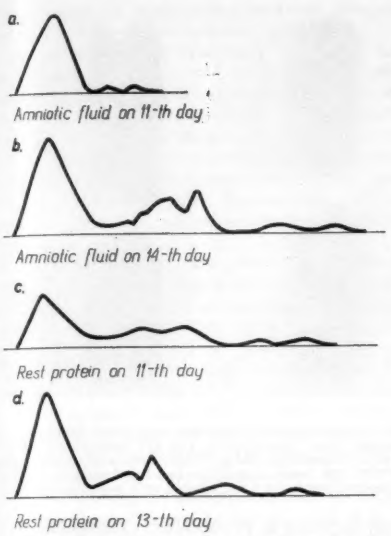

Fig. 1. Electrophoretic diagrams obtained in free electrophoresis in 'Fokal' *F* apparatus

The highly proteinous amniotic fluid of the fourteenth day contains five electrophoretically distinct fractions (Fig. 1*b*). The largest, amounting to 62 per cent of the total protein, presents a broad base in the diagram, which proves it to be inhomogeneous. The second, third and fourth fractions amount respectively to about 17, 10 and 8 per cent of the total protein. The latter fraction, in the buffer solution used, moves towards the cathode, and amounts to about 3 per cent of the total protein. The rest protein of incubated eggs on the eleventh and thirteenth days exhibited similar electrophoretic diagrams (Fig. 1*c* and *d*); the diagram on the eleventh day shows weakly developed gradients.

The similarity of the diagrams obtained with highly proteinous amniotic fluid and that of the rest protein of the incubated egg on its thirteenth day is noteworthy (Fig. 1*b* and *d*). It had already been observed by M. E. Marshall[3] in the amniotic fluid of the incubated egg and the protein from newly laid egg.

The biochemical changes in the composition of the amniotic fluid and in the amount of total protein, between the twelfth and fourteenth days of the life of the embryo, observed as a stepwise variation in the potassium ion and total protein contents and as variations in the electrophoretically separated protein fractions, are probably caused by the serum–amniotic junction.

I am indebted to Prof. Jan Adamski (Institute of Medical Microbiology, Medical Academy, Poznań) for the material received for investigation, and to Prof. Jan Roguski (IInd Clinic of Internal Medicine, Medical Academy, Poznań) for permission to carry out the electrophoretic analysis in his laboratory.

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Demonstration of Small Components in Red Cell Hæmolysates by Starch-gel Electrophoresis

Starch-gel electrophoresis[1] has been used successfully for the investigation of human and animal sera; it is superior to other methods because it affords greater resolution and ability to demonstrate small components. The same method has also been applied to the study of human hæmoglobin, although the results reported so far[2–4] have not provided information different from that obtainable by other electrophoretic techniques.

We have used this supporting medium with phosphate buffer (*p*H 6·5, Γ/2 0·033) in the electrode vessels and for the preparation of the gels (12 gm./100 ml. of hydrolysed starch, Connaught Laboratories, Toronto). The hæmoglobin solution (10–15 gm./100 ml.) is introduced into suitable slits either on a double piece of filter paper (Whatman 3*MM*) or as a paste moulded with unboiled starch. Direct current at 280 V. and 26 m.amp. is applied for 6–8 hr. to two plastic trays, each measuring 250 mm. × 60 mm. × 6·5 mm. After completion of the run one of the cut surfaces is stained for protein[1] and the other is treated with a benzidine reagent[2]; the concentration of hydrogen peroxide in the latter is preferably kept low (1–3 per mille) in order to avoid distortion of the gel by catalase activity.

A coloured zone at the position of hæmoglobin *A* is still demonstrable with benzidine when the hæmoglobin solution applied has been diluted to 1 part in 2,000, and with amidoschwartz at a dilution of 1 part in 500. The electrophoretic pattern appears similar whether the hæmolysate is freed of stromal material by extraction with toluene, by precipitation with phosphate buffer (0·3 *M*, *p*H 6·8) or by high-speed centrifugation. For the identification of some zones a two-dimensional technique[5] has been applied (paper electrophoresis at *p*H 8·6 or 6·7, followed by starch-gel electrophoresis at *p*H 6·5 of segments cut longitudinally to the direction of migration).

Under the above conditions the normal hæmoglobins A_2, *F* and *A* move in that order a short distance toward the cathode, hæmoglobin *F* not separating from *A*; all other fractions migrate away from the point of insertion to the anode. By protein stain the following zones can regularly be observed (Fig. 1):

Zone 1, placed immediately after the slit of insertion, benzidine negative, is always present in adults, but is absent or only barely visible in cord blood; it corresponds to a protein which on paper, starch-

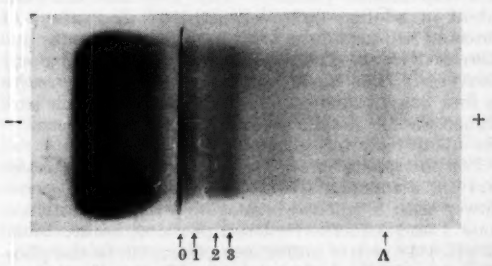

Fig. 1. Starch-gel electrophoresis of red cell hæmolysate from adult blood, 6 hr., amidoschwarz stain. 0, application slit. Numbers and letters correspond to zones described in text. The weaker fractions ahead of band Λ are not reproduced on the photograph

block and starch-gel electrophoresis at *p*H 8·6 migrates slightly more slowly than A_2.

Zone 2 is a narrow band, which probably corresponds to catalase, because oxygen is liberated only in this area; at low concentrations of hydrogen peroxide a thin benzidine-positive line appears in this region.

Zone 3, closely following 2, is very prominent and occurs in both adult and cord blood. It is followed by a number (usually 3–4) of weak and less sharply delineated bands, which have not been identified.

The zone designated A occupies the same position as serum albumin; in the presence of traces of serum in the hæmolysate this band stains more intensely and, at times, may also be demonstrated by the benzidine reagent as a weak line. This observation suggests binding of hæmoglobin or its derivatives by albumin. A zone with similar properties is also demonstrable on starch gels used with borate buffer, *p*H 8·4; in both buffers it is of definitely higher anodic mobility than hæmoglobin *H* (Fig. 2). The characteristics of this zone are reminiscent of the small fraction *V* observed by Huisman and Martis in many samples by chromatography on carboxymethylcellulose[6].

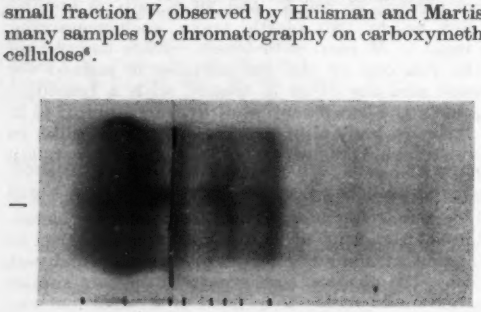

Fig. 2. Electrophoresis of hæmoglobin from an adult with hæmoglobin *H*, 8 hr., amidoschwarz stain. Symbols as for Fig. 1; *f* indicates relative position of 'fast' fœtal hæmoglobin

Three further very weak zones, not identified, precede band A towards the anode.

By means of the benzidine reagent we were able to demonstrate in all samples of cord blood a well-defined zone with peroxidase activity, situated only slightly ahead of zone 3 (Fig. 3); it is estimated to amount to 0·5–1 per cent of the total hæmoglobin. The position of this band, as well as evidence obtained by the two-dimensional technique, strongly suggest that it corresponds to a 'fast' fœtal hæmoglobin, increased levels of which have been observed in several cases by paper electrophoresis (ref. 7 and Vella, F., and Lie-Injo Luan Eng, personal communications and unpublished results). This zone has not been found in adults; however, minimal amounts were detected in four adults with hereditary anæmias and increased levels of hæmoglobin *F* (12–20 per cent). Conversely, this same fraction was definitely present in four cases presenting hæmoglobin *H*—which is of higher anodic mobility—and a minimal increase of the alkali-resistant pigment.

For the separation of certain hæmoglobin variants and of components which at alkaline *p*H move slower than *A* (such as hæmoglobin A_2, the protein of zone 1 and a further red cell protein), borate buffer at *p*H 8·4[1] or *tris* buffer[3] are preferable to the phosphate used here; hæmoglobin *H*, the 'fast' fœtal fraction and zone A can also be demonstrated in borate buffer. However, the delineation of components with a higher anodic mobility than hæmoglobin *A* is

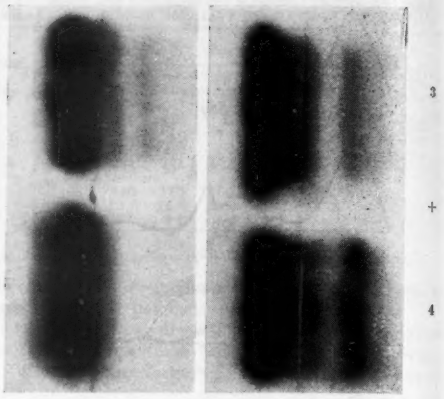

Fig. 3. Comparison of (1) normal cord blood hæmoglobin with (2) normal adult hæmoglobin, and (3) hæmoglobin from cord blood of a 6 months premature infant with (4) cord blood presenting a very high percentage of the fast fœtal fraction. Starch gel electrophoresis for 6 hr., treated with benzidine reagent

generally superior in phosphate. Furthermore, under the above conditions, the mobility of the zones is not affected by their relative concentration.

It is believed that this method, although not yet suitable for accurate, quantitative use, has the advantage of clearly demonstrating minor components of red cell hæmolysates, not well shown by other electrophoretic procedures. Work on the nature of the zones observed and their alterations in various conditions is in progress.

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Distribution of Alkaline Phosphatase in the Arteries of Several Species

A chance observation in our laboratory led us to study the activity of the alkaline non-specific monoesterase in the arterial wall. The distribution of this enzyme within the arteries has received but scant attention and contradictory reports appear in the literature. Kay[1] states that none is found when chemical methods are used, whereas Gomori[2], using a histochemical technique, reports that the enzyme is found in the adventitia of medium-sized arteries. In the human being, no activity has been found[3] chemically in the aorta at an alkaline *p*H, or only traces found in this vessel and in other arteries[4]; on the other hand, the enzyme has been demonstrated

histochemically in early atheromatous plaques[5] as well as chemically in peripheral arteries[6].

The present observations show that the activity of alkaline phosphatase is not uniform and that there are differences between arterial territories as well as between species; it seems possible that conflicting reports may be due to this fact. Furthermore, an interesting and unexplained fact has been disclosed, namely, an apparent inverse relationship between the enzyme activity and the ability of several species to develop atherosclerosis induced by cholesterol.

Rabbits, chickens and rats were anæsthetized with sodium pentobarbital, blood collected and the arterial system perfused with saline in order to avoid contamination with blood. The aorta and the cerebral vessels (free from the choroid plexus) were removed, blotted with filter paper and weighed; they were then frozen and cut into 10μ sections with a microtome, homogenized and the enzyme activity in approximately 20 mgm. of tissue determined by the method described by Kaplan and Narahara for blood serum[7]. Incubation was carried out at 37° C. for 30 min. with disodium phenylphosphate as substrate, and with sodium borate buffer at *p*H 9·4. The enzyme was also determined in citrated plasma.

The results, expressed in μmoles of phenol liberated under the stated conditions, are shown in Table 1. It can be seen that the alkaline phosphatase activity is similar in the plasma of rabbits (50·1 ± 7·17 μmoles/ml., mean ± standard error) and rats (60·9 ± 4·40) whereas it is much higher in chickens (303·0 ± 24·7). In the aorta, however, the activity was very low in rabbits (0·06 ± 0·006) and in chickens (0·14 ± 0·018), while it was 0·48 ± 0·028 in the rat. In the cerebral vessels it was strikingly higher and also different in the three species (0·21, 2·74 and 1·10, in the rabbit, rat and chicken respectively). It must thus be concluded that the alkaline phosphatase content of the vessels is not the same in different species, that plasma values bear no relationship to the arterial activity and that the cerebral vessels have a much greater enzymatic concentration than the aorta.

Table 1. Alkaline Phosphatase Activity in Several Species (in μmoles of Phenol Liberated under Standardized Conditions; Mean ± Standard Error)

Animal	Plasma (per ml.)	Aorta (per mgm. of wet tissue)	Cerebral vessels (per mgm. of wet tissue)
Rabbit	(18) 50·1 ± 7·17	(14) 0·06 ± 0·006	0·21*
Rat	(12) 60·9 ± 4·40	(16) 0·48 ± 0·028	2·74†
Chicken	(10) 303·0 ± 24·7	(10) 0·14 ± 0·018	1·10†

All determinations were carried out in duplicate; figures in parentheses, number of animals.

* Six determinations on pools of three animals.

† Two determinations on pools of six animals.

Although very little is known about the chemical reactions which might be catalysed by alkaline phosphatase in the arterial wall, the changes that the enzyme might undergo in different circumstances seem to be worthy of study. Finally, it is also of interest in connexion with the problem of atherosclerosis, that in rabbits and chickens atherosclerosis is easily induced by cholesterol[8], and they have very little alkaline phosphatase in the aorta, whereas rats show a high enzymatic activity and very rarely develop the disease[9]; furthermore, cerebral lesions are not seen even in atheromatous rabbits which have been fed cholesterol[10] and, as was shown, the cerebral vessels possess a high alkaline phosphatase activity. Further work on these apparent relationships is clearly needed and is being undertaken in our laboratory. Results will be published in more detail elsewhere.

We are grateful to Prof. Eduardo Braun Menendez for helpful suggestions and criticisms.

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A Germination Inhibitor and Root-Growth Retarder in Chou Moellier (*Brassica oleracea* var.)

Investigations are being undertaken at this Station into local problems associated with the establishment of new pastures. Such pastures are commonly sown in the autumn following a summer crop of chou moellier (marrow stem kale), *Brassica oleracea* var. A frequent outcome of such sowings is that the grass components of the seeds mixture germinate and grow apparently normally, while the legume component may or may not germinate. If the seeds of the legume component (chiefly white clover) do germinate, and seedlings emerge, they frequently die off in four to six weeks.

In the course of *in vitro* studies undertaken to throw light on this problem of clover seedling mortality the presence of a germination inhibitor in chou moellier has been demonstrated. A technique has been used in which ten white clover (*Trifolium repens*) seeds are sown on a filter paper in a Petri dish, while on a second filter paper slightly overlapping the first are placed sections of chou roots, stems or leaves, or finely minced parts of these organs. The seeds are then provided with sufficient moisture for germination by applying water to the chou plant material and allowing it to pass to the seeds across the bridge formed by the overlapping filter papers.

The germination in eight days of white clover seeds has been reduced from 87 per cent in the controls to 10 per cent where minced chou roots were present on the adjacent filter paper, with lesser reductions in germination where minced stems and leaves and unminced sections of the roots were present.

The inhibitory effect appears to be irreversible, since ungerminated seeds removed after eight days from the presence of chou roots, leaves and stems to clean filter paper in Petri dishes uncontaminated by chou plant material and watered with

distilled water failed to germinate after a further ten days.

In the few cases where clover seeds were able to germinate in the presence of chou moellier roots, the seedling radicles became blackened at the tip, root hairs were very sparse by comparison with the control seedlings, and within three weeks the seedlings adjacent to the chou roots had all died.

Evaluation of the part played by the inhibitor in the field mortality of clover seedlings awaits the result of field trials now in progress.

The effect of the inhibitor has also been studied in relation to germination and subsequent growth of perennial ryegrass (*Lolium perenne*) and New Zealand short rotation ryegrass (*L. perenne* × *L. multiflorum*). With neither species did the presence of chou roots, leaves or stems reduce germination percentage. However, using the technique outlined above for clovers, the presence of sections of chou roots on the adjacent filter paper had a most striking effect on the total root length per rye-grass seedling. The mean root lengths in millimetres, for 30 seedlings in each case, are given in Table 1.

Table 1

	Controls	With chou roots
Perennial rye-grass	24 mm.	5 mm.
Short rotation rye-grass	26 mm.	1 mm.

Later observations suggest that parts of the swede turnip plant and of the common weed spurrey (*Spergula arvensis*) may have similar effects.

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Enzymic Nature of the Serum Globulin Permeability Factor

The globulin permeability factors obtainable from the serum of man[1], guinea pig[2,3], rat[4] and rabbit[4] appear to be proteases because they are highly active on vascular endothelium—on a molar basis, they are 60–2,000 times as active as histamine, itself a potent permeability factor[5]; and because they are readily inhibited by prior treatment *in vitro* with the trypsin inhibitors from soya bean, lima bean and bovine pancreas. The action of these inhibitors, however, is apparently very rapid, a mixture of factor and inhibitor only 1 min. old being inactive when injected into the skin of animals with circulating pontamine blue[4,7]. Consequently, it is impossible to distinguish inactivation of a protease permeability factor *in vitro* from inactivation of a protease newly activated *in vivo*. Moreover, even the best preparations of permeability factors also contain known serum proteases, and so far no enzyme substrate has been found which is hydrolysed by serum fractions in strict proportion to their content of permeability factor.

The enzymic nature of the factors was more firmly established when one of us (E. L. B.[6]) demonstrated that guinea pig permeability globulin was irreversibly inactivated by prior treatment *in vitro* with di*iso*propyl phosphofluoridate and subsequent dialysis to to remove excess di*iso*propyl phosphofluoridate. Thus, treatment with $4{\cdot}4 \times 10^{-4}$ *M* di*iso*propyl phosphofluoridate for 2 hr. at 37° completely inactivates 54 'effective blueing doses' (EBD)[7]. Since the inactivation *in vitro* (Table 1) is slow and progressive, the drug cannot be suppressing a protease activated *in vivo*. Furthermore, the minimally effective concentration of di*iso*propyl phosphofluoridate for inactivation at 37° C. for 1 hr. is of the order of 10^{-5} *M*, a concentration like that inactivating trypsin, in contrast to concentrations of 10^{-8}–10^{-9} *M* effective on enzymes with a more restricted esterase activity[8], for example, choline esterase.

Table 1. Progressive Inhibition of Permeability-increasing Potency of Guinea Pig Factor by Prior Treatment *in vitro* with Di*iso*propyl Phosphofluoridate (DFP)

Amt. factor (EBD)	Concn. DFP (*M*)	Percentage inhibition after treatment with DFP for			
		½ hr.	1 hr.	2 hr.	6 hr.
2	$3{\cdot}3 \times 10^{-6}$	*nt*	*nt*	33	39
2	1×10^{-5}	39	59	75	75
6	1×10^{-5}	*nt*	48	89	92
6	$3{\cdot}3 \times 10^{-5}$	50	63	82	98
18	1×10^{-4}	39	83	96	100

EBD, Effective blueing dose; *nt*, not tested.

Nevertheless, the factors in guinea pig and rat serum, if they are enzymes, appear to attack ester linkages. Thus 0·01 *M* of both *p*-toluene sulphonyl L-arginine methyl ester and of benzoyl L-arginine methyl ester prevent inactivation of the guinea pig factor by $2{\cdot}5 \times 10^{-4}$ *M* di*iso*propyl phosphofluoridate. The ethyl esters of L-leucine, L-lysine, L-phenylalanine, DL-serine, L-tyrosine and acetyl L-tyrosine were ineffective in concentrations of 0·01 *M*. Rat factor is also protected by *p*-toluene sulphonyl L-arginine methyl ester, 0·003 *M* successfully competing with 10^{-3} *M* di*iso*propyl phosphofluoridate. These facts are compatible with the serum factors being proteolytic enzymes with an active site similar to that of trypsin. They are distinguished from trypsin by their insusceptibility to the trypsin inhibitor in ovomucoid[9]. The direct competitive inhibition of the factor by these synthetic amino-acid esters cannot be satisfactorily tested *in vivo* because they are themselves fairly potent permeability factors.

When partially purified preparations of guinea pig factor were fractionated on an N,N-diethylaminoethyl–cellulose column the permeability factor activity was associated with a soya bean inhibitable esterase with a *p*H optimum around 9·0. Treatment of cell-free guinea pig serum with glass particles, which activates the permeability factor[10], also activates a soya bean inhibitable esterase with a *p*H optimum around 9.

Under standard conditions, a fixed dose of di*iso*propyl phosphofluoridate has a remarkably similar effect on the permeability factors from guinea pig, rat and rabbit whether they are tested in the corresponding homologous animal or in either of the two heterologous animals. Prior treatment *in vitro* with 10^{-4} *M* di*iso*propyl phosphofluoridate for 60 min. at 37° C. decreases the permeability-increasing potency in all cases by a factor of about 3, the extreme values being 1·8 and 4·4. It is of interest that the esterase inhibitors[8] diethyl *p*-nitrophenyl phosphate (*E* 600), tetraethyl pyrophosphate and *bis*-mono*iso*propyl aminofluorophosphine oxide, in concentrations up to 3×10^{-4} *M*, do not inactivate the factors, though tetraethyl pyrophosphate has a slight effect at 3×10^{-3} *M*. Systemic tri-O-cresyl phosphate is converted in the liver into an inhibitor of serum and

liver aliesterases[11]; when given 4 and 24 hr. previously in the rat, it did not substantially inhibit the permeability effect of histamine, 5-hydroxytryptamine, the histamine-liberating compound 48/80 or rat-serum factor.

The use of di*iso*propyl phosphofluoridate has enabled us to establish more firmly the hypothesis that the globulin permeability factors are proteases. The drug is also useful for distinguishing the permeability effects of the globulin from those of other endogenous factors. Di*iso*propyl phosphofluoridate has no *in vitro* effect on histamine, tested in all three species of animal, or on compound 48/80 and 5-hydroxytryptamine, tested in the rat. But its use as an *in vivo* reagent for identifying effects due to the globulin factors is limited by its toxicity in concentrations that might be expected to inactivate proteases. Thus, 0·1 ml. of 10^{-4} *M* di*iso*propyl phosphofluoridate given intracutaneously is sufficient to induce local fibrillation in the muscles of the skin. Given systemically, di*iso*propyl phosphofluoridate is likely to be even less useful for this purpose, because in non-toxic doses it will effect mainly the numerous esterases of the body susceptible to concentrations of the order of 10^{-8}–10^{-9} *M*.

In contradistinction to the observations of Spector and Willoughby[12] in the rat, in our hands only obviously toxic doses of systemic di*iso*propyl phosphofluoridate decreased the action of globulin permeability factors injected intracutaneously in both rats and guinea pigs. In any event, the action of the globulin factors is not exclusively affected, since the permeability effects of histamine, compound 48/80 and 5-hydroxytryptamine in rats and guinea pigs are depressed to the same extent.

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Equilibration of Labelled Magnesium between Sheep Plasma and Red Cells

The following work was undertaken to determine the rate of transfer of magnesium across the sheep erythrocyte membrane held in a stable *in vitro* system. It is considered that such information should be of value in the elucidation of the etiology of hypomagnesæmia.

Samples of heparinized sheep blood, to which a known percentage of isotonic glucose containing carrier-free magnesium-28 had been added, were incubated for different periods at 40° C. During this incubation frequent aeration with a water-saturated gaseous mixture of 5 per cent carbon dioxide and 95 per cent oxygen was carried out. A layer of paraffin above the blood prevented the interchange of gases between the blood and its environment except during aeration. After each relevant period the particular sample was centrifuged under paraffin, *p*H measured and the plasma and erythrocytes separated. The magnesium-28 was counted in each sample and its total magnesium estimated chemically by way of ammonium vanadate (Rook, J. A. F., private communication).

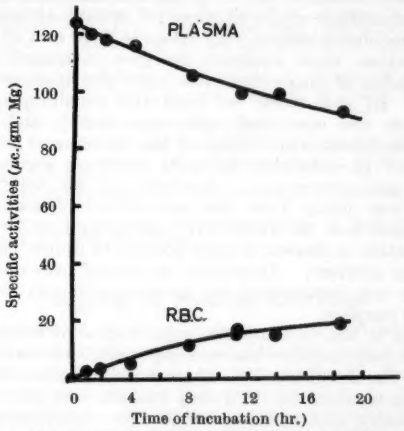

Fig. 1. Magnesium-28 exchange between plasma and red cells of sheep blood

The changes with time of the specific activities of the plasma and erythrocyte magnesium were determined (Fig. 1). The rate of transfer of magnesium between the extracellular and intracellular compartments was calculated by the method used for potassium exchange[1]. It amounted to 3·4 per cent of the plasma magnesium content per hour.

In order to investigate any effect exerted by *p*H on this magnesium transport, the above experiment was repeated at different blood *p*H's. The results showed no significant effect of *p*H on the rate of transport of magnesium between plasma and erythrocytes *in vitro* over the *p*H range studied (7·26–8·07).

The above work, in detail, along with its extension to *in vivo* experiments with sheep, will be published shortly elsewhere.

We wish to record our appreciation for the financial assistance afforded us by the Secretary of State for Scotland and by the Animal Health Trust to one of us (A. D. C.).

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Detection of Carriers in Hereditary Galactosæmia

Attempts are being made[1] to detect the heterozygous state for galactosæmia by means of the uridine diphosphoglucose consumption test on erythrocytes—a test devised by us for the detection of galactosæmia[2]. This test was designed so as to give a maximum of difference between normal persons and persons having congenital galactosæmia, in which no galactose-1-phosphate uridyl transferase is discernible in erythrocytes[3,4]. In order to magnify this difference and hence provide an unambiguous proof for the clinician[2,3] this reaction mixture is over-incubated. With near-normal activities, the reaction is brought close to the equilibrium point (cf. refs. 2, 4, 5), and the rates measured are obviously not maximum rates. Experiments in which aliquots for uridine diphosphoglucose determination were taken at 5, 10 and 20 min. incubation time designed to give a quantitative expression of maximum rates have also been carried out[5]. In this work we used the consumption as well as the combined epimerase test[2,3], and yet, only in about two-thirds of the specimens did we succeed in obtaining linearity between incubation time and conversion. Accordingly, we believe it even less likely that the unmodified clinical consumption test (in which only one aliquot at 30 min. incubation is drawn) should be able to detect heterozygous carriers. Therefore, as stated previously[2,6], we do not recommend the consumption test for the latter purpose.

This is not to deny the high degree of reliability of the consumption test and especially our combined test[2,3] for detecting homozygous individuals afflicted with galactosæmia. Not only has the test proved to be reliable and specific, but it also circumvents the loading of afflicted infants with galactose. Moreover, as suggested by Dr. H. N. Kirkman[7], a slight modification of the test may prove useful in spotting galactose-1-phosphate in blood and hence turn attention toward possible faulty diets in case of galactosæmia[7].

We have pointed out on earlier occasions[2,6] that in order to develop reliable techniques for detecting heterozygous carriers in galactosæmia it is necessary to develop methods in which it is possible to obtain accurate and abundant results under conditions in which one can expect maximum rates for galactose-1-phosphate uridyl transferase. Such methods, which were developed more than a year ago by Dr. Kirkman[8], permit the recording of 20–25 points during the period in which the reaction is proceeding at maximum rate. The first results, which were reported some time ago[9], showed that the parents of galactosæmic children frequently manifest partial defects in the above-mentioned enzyme. In a more detailed publication[8] Kirkman evaluates the method and the results. It seems that this method permits the detection of an enzyme defect in the great majority of carriers of hereditary galactosæmia.

Note added in proof: A paper dealing with galactosæmia carriers has recently appeared (Brettauer *et al.*, *Proc. U.S. Nat. Acad. Sci.*, **45**, 328; 1959) which describes preliminary results obtained with a similar modification of our diagnostic methods[2], namely, shorter incubation time and higher substrate concentrations. Values for transferase activity in hæmolysates ranging between 4·8 and 8·1 μmoles/hr./gm. cells are reported. In a smaller survey I found values ranging between 4·0 and 5·8 μmoles/hr./gm. (unpublished work).

We also agree with Brettauer *et al.* that the modified diagnostic method makes it possible to find markedly lower enzyme values in hæmolysates from parents of galactosæmic children. I have found values as slow as 1·2–2·2 μmoles/hr./gm. cells. In spite of these differences we cannot recommend the "one point method" for use in the diagnosis of individual carriers. The manometric method as described by Kirkman gives a guarantee that one is really dealing with zero-order kinetics and we believe that at the present time it is the only test which can be used in the diagnosis of carriers in families in which galactosæmia has not been observed before. A detailed discussion of these problems will be given elsewhere.

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Gene Action in Erythrocyte Deficiency of Glucose-6-phosphate Dehydrogenase: Tissue Enzyme-Levels

The susceptibility to increased hæmolysis following ingestion of such agents as primaquine, naphthaline, nitrofurans, other drugs and the fava bean is associated with intrinsic defects in erythrocyte metabolism. These defects include a lower concentration of reduced glutathione[1], instability of reduced glutathione during incubation of the cells with acetylphenylhydrazine[2], and a deficiency in glucose-6-phosphate dehydrogenase[3]. Recent studies have suggested that this erythrocyte enzymatic deficiency is genetically determined, and inherited as a sex-linked characteristic of intermediate dominance[4–6].

In this investigation, it has been found that subjects with an erythrocyte deficiency of glucose-6-phosphate dehydrogenase have normal levels of this enzyme in their leucocytes. In addition, two subjects with markedly deficient erythrocyte glucose-6-phosphate dehydrogenase did not have a similarly decreased level of this enzyme in their liver.

Leucocytes were separated from venous blood by a method of dextran flotation which yields a white blood cell preparation contaminated with fewer than 5 red cells for each leucocyte[7]. This degree of contamination by red cells does not affect the assays of leucocyte enzyme. The leucocytes were suspended in approximately 20 vol. of isotonic potassium chloride buffered at *p*H 7·4 and disrupted by freezing and thawing three times. Leucocyte counts were performed prior to, and following, this procedure to ensure that assays were performed only on samples in which more than 90 per cent of the white blood cells were destroyed. Liver tissue was obtained by surgical biopsy through an abdominal incision. This tissue was homogenized and resuspended in isotonic

potassium chloride buffered at *p*H 7·4. The erythrocytes were prepared as previously described[8]. Glucose-6-phosphate dehydrogenase, 6-phosphogluconic dehydrogenase and purine nucleoside phosphorylase were assayed by techniques described elsewhere[8].

In subjects whose red cells were markedly deficient in glucose-6-phosphate dehydrogenase, the leucocyte content of this enzyme was not significantly different from that in leucocytes of the control group (Table 1). Glucose-6-phosphate dehydrogenase activity was markedly higher (on a per 10^9 cell basis) in leucocytes than in erythrocytes. No significant differences were found in purine nucleoside phosphorylase activity of leucocytes or of erythrocytes of control subjects compared with persons with red cells deficient in glucose-6-phosphate dehydrogenase.

Table 1. GLUCOSE-6-PHOSPHATE DEHYDROGENASE ACTIVITY IN LEUCOCYTES AND RED CELLS OF CONTROL SUBJECTS AND PERSONS WITH A DEFICIENCY OF THIS ENZYME IN THEIR CIRCULATING ERYTHROCYTES

Subjects	Number	Leucocytes*	Red cells
Control	31	37·3 ± 5·8	0·49 ± 0·11
Deficient red cell *G-6-P.D.*†	14	36·8 ± 1·8	0·07 ± 0·01

* The unit of enzyme activity is expressed as the change in optical density per min. per 10^9 cells (△ opt. dens./min./10^9 cells). The mean values + or − one standard deviation are given.

† *G-6-P.D.*, glucose-6-phosphate dehydrogenase. All subjects included in this group had erythrocyte glucose-6-phosphate dehydrogenase levels below three standard deviations of the mean for the control group.

In 4 control subjects the level of glucose-6-phosphate dehydrogenase in liver was 0·081, 0·060, 0·58 and 0·088 units (change in optical density units per *min. per mgm. liver nitrogen*), respectively. Two subjects with erythrocyte glucose-6-phosphate dehydrogenase deficiency had levels of this enzyme in liver tissue of 0·052 and 0·040 units. 6-Phosphogluconic dehydrogenase activity in the liver of these subjects were 0·15 and 0·13 units compared with levels of 0·12, 0·17, 0·13 and 0·20 units in the control subjects, respectively.

These findings are of importance with respect to identification of the primary action of the genetic factor responsible for the deficiency in glucose-6-phosphate dehydrogenase in red cells of 'drug-sensitive' subjects. If the erythrocyte enzyme deficiency resulted from the direct action of a gene locus, all tissues of the affected organism might be expected to exhibit the lowered enzyme activity. The present studies suggest that erythrocyte glucose-6-phosphate dehydrogenase deficiency is not a primary but a more remote consequence of the presence of a genetic defect. No evidence for a glucose-6-phosphate dehydrogenase inhibitor was found in these red cells[9]. There is little or no protein synthesis in the mature erythrocyte[10,11]. As normal red cells age *in vivo*, there is a decrease in glucose-6-phosphate dehydrogenase activity[12]. A deficiency in erythrocyte dehydrogenase might result from an action of the gene affecting the turnover or stability of this enzyme in a manner such that its activity decreases more rapidly than normal as the red cell ages *in vivo*. Studies on the effect of age on glucose-6-phosphate dehydrogenase in erythrocytes of subjects whose red cells are deficient in this enzyme have revealed that young red cells have markedly higher activities than older cells[9].

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Ageing of Human Cartilage

IN a recent study of human costal cartilage, the isolation of kerato-sulphate in addition to chondroitin sulphate was reported in two cases of Marfan's syndrome and in two young adults free of skeletal abnormalities[1]. In earlier work on hyaline mammalian cartilage, including that of new-born infants, no keratosulphate fraction had been encountered[2]. Moreover, rib cartilage of the new-born yielded only chondroitin-4-sulphate (*A*), while in the adult the fraction was predominantly chondroitin-6-sulphate (*C*)[3]. These findings, as well as the demonstration of a shift from D-galactosamine to glucosamine with increasing age in epiphyseal human cartilage[4], suggested a study of the distribution of chondroitin sulphate and keratosulphate in rib cartilage of various age-groups.

Human rib cartilage was obtained at unselected autopsies (we thank the Department of Pathology for its collaboration in this connexion). The age ranged from new-born to 74 years. The ribs were cleaned of extraneous tissues, bony parts and perichondrium, and dried in acetone. The dried tissue was homogenized, digested with 'activated' commercial papain[5] at 70°C. (Scott, J. E., personal communication) and, after further purification, the acid mucopolysaccharides were fractionated and analysed for nitrogen, hexosamine, uronic acid, hexose and sulphate. A quantitative separation of chondroitin sulphate and keratosulphate was not attempted since in our experience separation of keratosulphate from chondroitin-6-sulphate has only been possible after enzymatic digestion of the latter with testicular hyaluronidase. The chondroitin sulphate and keratosulphate content of the fractions were calculated from the carbazole and anthrone values of the isolated fractions.

The chondroitin sulphate of the fractions as per cent dry weight of cartilage is shown in Fig. 1. The chrondroitin sulphate content appears to decrease

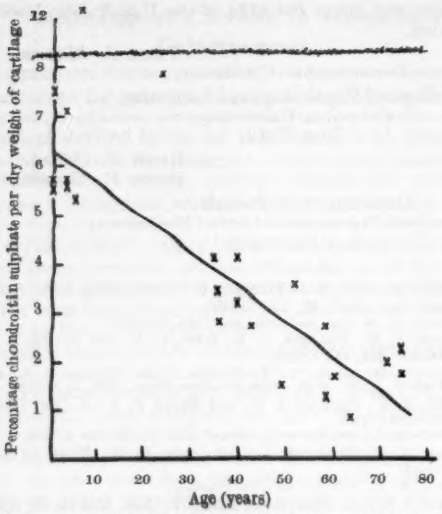

Fig. 1. Chondroitin sulphate content as percentage of dry weight of rib cartilage in relation to age

linearly with age. Keratosulphate was negligible or absent in the very young. It appears to reach a plateau at 20–30 years and to remain constant to the greatest ages investigated, where it represented approximately 50 per cent of the total mucopolysaccharide. When the ratio of keratosulphate to the total mucopolysaccharide is plotted against age, a linear increase is obtained as shown in Fig. 2. In this curve, the two cases of Marfan's syndrome (encircled crosses) fall within the upper range of the normal. Furthermore, costal cartilage from a young cow and a young pig, and tracheal cartilage from a young cow demonstrated similar ratios of keratosulphate to total mucopolysaccharide as do immature human beings.

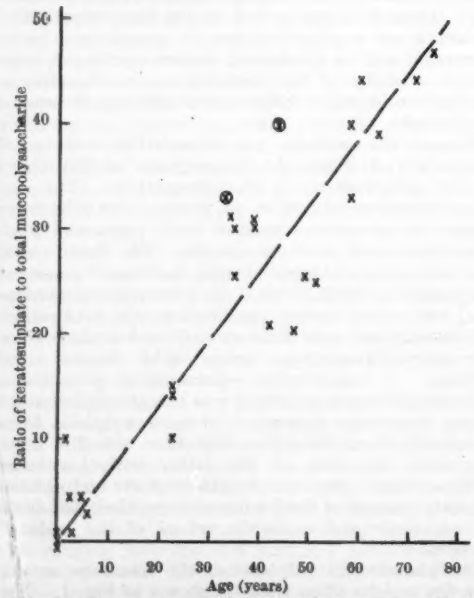

Fig. 2. Ratio of keratosulphate content to total mucopolysaccharide of rib cartilage in relation to age

Clinically, no correlation was found with sex (2/3 male, 1/3 female), with presence and degree of arteriosclerosis, or the state of nutrition (judged by degree of wasting as noted at autopsy). It may also be of interest that two of the subjects were on steroid therapy for more than two years, one had moderate osteoarthritis, one 34-year-old had bone disease and mild diabetes secondary to Cooley's anæmia.

The rib cartilage appears to be a tissue eminently suited for studies on ageing because it is less affected than other tissues by mechanical stresses, by the repeated insults of infection, and by the nutritional status. While the decrease in chondroitin sulphate content is continuous from birth to old age, the keratosulphate content increases to a plateau, which appears to be maintained even in senescence. The process of change with time in cartilage is thus more comparable to differentiation rather than to degeneration usually associated with ageing. It will be of interest to determine whether the time-schedule apparently inherent in this tissue can be influenced experimentally.

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Salt Concentration and Fibrinolytic Activity

The observation of gross spontaneous lysis in pathological states presents little difficulty, so long as there is some fibrinogen left to form an observable clot; but there is still no satisfactory method of assessing the normal blood fibrinolytic activity. The different test systems all disturb the balance of the fibrinolytic system, for example, by dilution, fractionation or introduction of abnormal clotting systems or change of *p*H. It is still debatable whether any method even approaches the state of affairs in a normal vessel, still less that in a thrombotic case where deposition of fibrin probably leads to local absorption of fibrinolytic components so that active enzyme is produced locally and clot lysis facilitated. This latter aspect is not directly approachable by *in vitro* methods; but it draws its reactants from the circulating blood, though in injury or anoxia tissue factors are also important, and so one aspect of the body's ability to deal with a clot is reflected in the blood fibrinolytic activity.

By apparently minor changes in the experimental conditions enormous variations can be produced in the fibrinolytic activity of the same blood sample. To compare results it is necessary to have a rigidly standardized assay system, and sufficient attention

Table 1. Effect of Varying Sodium Chloride Concentration on Plasma Fibrinolytic Activity by Partial Lysis Method

Plasma	Sodium chloride in reaction mixture (per cent)	6-hr. lysis	24-hr. lysis
1	0	14·5	100
	0·3	75	100
	0·6	13·5	100
	1·0	0	97
2	0	50	100
	0·25	96	100
	0·5	26	100
	0·75	3	80
	1·0	0	4·5

Table 2. Lysis Times (min.) of Bovine Fibrinogen by Streptokinase-Activated Human Plasma

Sodium chloride in reaction mixture (per cent)	Plasma 1	Plasma 2	Plasma 3
0	49	42	43·5
0·2	17	21	21·5
0·4	14	18	18
0·6	15	17·5	19·5
0·8	18	20	21
1·0	28·5	24	31

has not been paid to the effect of salt concentration. We show here some typical results of varying the salt concentration on the fibrinolytic activity of fresh, cold-collected, citrated human plasma as measured by the partial lysis method (Table 1) and on the total potential fibrinolytic activity as measured by streptokinase activation followed by lysis of bovine fibrin (Table 2).

Further experiments have shown that this effect is also obtained with salts other than sodium chloride, and there appears to be a relationship between fibrinolytic activity and the ionic strength of the reaction mixture. These results will be reported fully elsewhere.

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Characterization of a Second Yellow Compound from *Drosophila melanogaster*

Hadorn and Mitchell[1] demonstrated by simple chromatographic techniques the presence of two yellow, yellow-fluorescent compounds in *Drosophila melanogaster*. Both these compounds are accumulated in the *sepia* mutant, and one of them (*F* 1 5), which is by far the major component, has been isolated in crystalline form[2]. A structure has been postulated for it[3], although this has had to be modified recently in the light of some new experiments on the compound to be described in this communication. The second component (*F* 1 7) is present in extremely small amounts even in the *sepia* mutant, and at such low levels it is very sensitive to light. However, we have succeeded in isolating a small amount of this material in crystalline form and have been able to demonstrate that it is indistinguishable from a yellow compound (compound *A*) which is found in comparatively large quantities in the blue-green alga, *Anacystis nidulans*[4,5].

A 6 per cent trichloracetic acid extract of 30 gm. of flies (*D. melanogaster*; mutant *sepia*) was passed through an acid-washed 'Florisil' column. The yellow fluorescent materials were concentrated in a band at the top of the column, and after the column had been thoroughly washed with dilute acetic acid and water, this band was eluated with 20 per cent aqueous acetone. The eluate was concentrated and then streaked on heavy filter paper (Whatman No. 17). A descending chromatogram was developed with butanol/acetic acid/water (4 : 1 : 1), and the faster-moving yellow compound was collected as a fraction when the solvent was allowed to drip off the paper. After evaporation of this fraction to dryness in the dark and *in vacuo*, a solution of the residue was again passed through a 'Florisil' column. The yellow eluate obtained by washing this with 20 per cent acetone was evaporated to small bulk, when the product crystallized in tiny yellow needles.

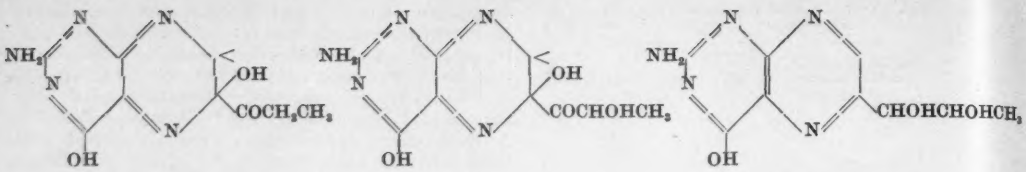
The absorption spectrum of this material was identical with that of the main yellow substance from *Drosophila* and with compound *A* from *Anacystis nidulans*[3,4]. Its paper chromatographic behaviour was identical with that of compound *A* (Table 1). Furthermore, on decomposition with bromine water, a colourless, blue-fluorescent material was obtained which again was identical paper chromatographically and spectroscopically with the analogously prepared derivative of compound *A*. Lastly, in alkaline solution, this yellow compound was readily oxidized to xanthopterin—again[5] a characteristic reaction of compound *A*.

Table 1

Solvent	R_F			
			Bromine decomposition products	
	Compound *A*	*F* 1 7	Compound *A*	*F* 1 7
n-Propanol/1 per cent ammonia (2 : 1)	0·78	0·78	0·82	0·82
n-Butanol/acetic acid/water (4 : 1 : 1)	0·75	0·75	0·73	0·73
n-Butanol/methyl-ethyl ketone/ammonia/water (5 : 3 : 1 : 1)	0·21	0·21	0·23	0·23
sec.-Butanol/formic acid/water (8 : 2 : 5)	0·32	0·32	0·27	0·27

Drosophila melanogaster, then, contains as a normal constituent, albeit in very small amount, the same yellow pteridine as is found in *Anacystis nidulans* and which is probably xanthopterin B_1[6] and bufo-yellow 2[7]. The structure proposed for this compound (I) and the revised structure for the main yellow pigment from *Drosophila* (II), show that they are quite simply related, I being the deoxy derivative of II. It is not difficult to visualize how the two side-chains on these compounds could arise from a common precursor, the dihydroxypropyl side-chain of biopterin (III), by simple dehydration or oxidation. Whether these reactions occur biologically remains to be discovered.

The implications of these findings for the structures of the red eye pigments of *Drosophila* might also be outlined. There are at least three red eye pigments[8]. The presumed precursor for these is the main yellow compound accumulated by the *sepia* mutant which has no red eye pigments. It is possible, however, that the three red compounds arise from three different, but closely related, yellow precursors, two of which are mentioned in this communication, a third remaining to be discovered (a third possible compound, for example, would be one containing a $CH_2OHCHOHCO$— side-chain at the 6-position.



I II III

This would be reasonable in view of the similar biological activity of biopterin and its trihydroxypropyl analogue[8]). A simple chemical change, for example hydroxylation of the 7-position, or further oxidation would then convert these yellow compounds into the closely related red pigments. Further work on this aspect and on the biochemistry of these compounds is being undertaken.

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Activity of 10-Hydroxydecenoic Acid from Royal Jelly against Experimental Leukæmia and Ascitic Tumours

Despite many investigations of royal jelly[1], its chemistry and pharmacological activity have not been completely established. As part of a long-term study on the chemistry and biological activity of royal jelly[2] we have recently investigated its possible anti-tumour properties. In this communication we wish to report that admixture of royal jelly with tumour cells before inoculation completely suppresses the development of a transplantable mouse leukæmia and the formation of ascitic tumours in mice. Fractionation studies have established that this anti-tumour activity resides in the main fatty acid of the royal jelly—10-hydroxydecenoic acid.

Anti-leukæmia studies were carried out by the method of Burchenal *et al.*[3] using female mice, 5–6 weeks of age, of the *AKR* strain. Cell suspensions were prepared in Gey's balanced salt solution[4] from the spleen of a mouse dying from spontaneous leukæmia. To these suspensions were added whole royal jelly, various fractions of royal jelly, or a standard citric acid or phosphoric acid buffer. The *p*H of each mixture was determined. The mixture was then shaken and immediately injected subcutaneously at a dose of 0·2 ml. per mouse. Each mouse received 2–5 million cells, as measured by direct hæmacytometer counts. Mixing of the tumour cells with test materials prior to injection has been employed in other investigations of a similar nature[5].

The criterion used in these experiments was survival: the mice either developed leukæmia or were protected. Each dead mouse was examined both grossly and microscopically by liver and spleen section to determine the extent of leukæmia infiltration. First transfers from mice with spontaneous leukæmia caused death in approximately 50 days; but successive transfers caused death more rapidly, in some cases within 16 days. The results of the anti-leukæmia experiments are summarized in Table 1.

Table 1. Effect of Royal Jelly and 10-Hydroxydecenoic Acid on Survival of Mice when mixed with Leukæmic or Ascitic Tumour Cells prior to Injection

Mixture*	No. of mice	*p*H of mixture	Protection†
Leukæmic cells plus:			
30 mgm. fresh royal jelly	41	4·2–4·8	+
15 mgm. fresh royal jelly	14	5·5–6·5	−
1·5 mgm. 10-hydroxydecenoic acid	32	4·2–4·8	+
1·0 mgm. 10-hydroxydecenoic acid	12	5·1–6·1	−
Citric acid buffer only	7	4·2	−
Phosphoric acid buffer only	16	5·3–5·8	−
2·0 mgm. 10-hydroxydecenoic acid	20	4·7–5·6	+
2·0 mgm. 10-hydroxydecenoic acid	26	6·1–7·3	−
6C3*HED* lymphosarcoma cells plus:			
100 mgm. whole royal jelly	212	5·9–6·1	+
100 mgm. whole royal jelly	52	7·2	−
1·0 mgm. 10-hydroxydecenoic acid	28	4·2	+
1·0 mgm. 10-hydroxydecenoic acid	28	6·9	−
0·6 mgm. 10-hydroxydecenoic acid	24	4·2	−
Buffer only	64	4·2	−
Buffer only	278	6·9–7·4	−

* Materials indicated as mgm. per ml. of cell suspension. In leukæmia experiments, each mouse received 0·2 ml. of mixture; in ascites experiments, each mouse received 0·5 ml. of mixture.

† +, Survival beyond six months. −, 100 per cent death in 21–54 days with the leukæmic cells and 100 per cent death in 12–15 days with 6C3*HED* cells.

Anti-tumour studies were conducted in three lines of ascitic tumours: the 6C3*HED* lymphosarcoma, the *TA*3 mammary carcinoma, and the Ehrlich carcinoma. Initially, these tumours were carried in the tumour-specific mouse strains; but in later experiments all three tumours were carried in the non-specific Connaught mouse line, following the freezing procedure of Morgan *et al.*[6]. Ascitic cells were harvested by intraperitoneal puncture, mixed with 2 vol. water to lyse any red cells present, centrifuged, and resuspended in Hanks's balanced salt solution[7] to the desired cell count. This suspension was mixed with the appropriate amount of whole royal jelly or fraction of royal jelly at different *p*H-levels, and was then administered intraperitoneally to large groups of mice (10–30) in 0·5-ml. doses. Each mouse normally received 5–8 million tumour cells; but in some cases doses of 10–20 million cells were used.

As in the anti-leukæmia experiments, the criterion was survival: control mice died from ascitic tumours in less than 14 days, while mice receiving appro-

priate mixtures of cells and royal jelly all failed to develop tumours. Protected mice were kept under observation for 90 days after death of the control mice. They were then killed, and random individuals autopsied to confirm the absence of tumours. The results of these studies are also summarized in Table 1. To conserve space, only experiments with the *6C3HED* lymphosarcoma are reported, although identical results were obtained with the other two tumours, and only the active fraction, 10-hydroxydecenoic acid, is listed.

The results summarized in Table 1 indicate that 30 mgm. of fresh whole royal jelly or 1·5 mgm. of 10-hydroxydecenoic acid per ml. of cell suspension inhibited completely the development of transplantable leukæmia in *AKR* mice. This effect was obtained only when the active material was mixed with the leukæmic cells prior to administration. Attempts to demonstrate protection after tumour implantation or by separate administrations of royal jelly and leukæmic cells have as yet been unsuccessful. The anti-leukæmic activity was demonstrated only at *p*H values below 6·0; but leukæmic cells alone, buffered to the same *p*H-range, caused death from leukæmia within the normal time.

Results of the anti-ascites experiments (Table 1) are very similar to the anti-leukæmia observations. Both whole royal jelly and its constituent 10-hydroxydecenoic acid prevent the development of ascitic tumours in mice. Somewhat higher concentrations of material are required than with the transplantable leukæmia. Approximately 100 mgm. of fresh whole royal jelly or 1·0 mgm. of 10-hydroxydecenoic acid per ml. of cell suspension were required for complete protection. At lower dosages, development of the ascitic tumours was delayed for 5 to 6 days. Afterwards, rapid tumour formation and death of the mice ensued in all cases. As in the leukæmia experiments, an acid *p*H and admixture of the royal jelly or fatty acid with the tumour cells prior to injection were required to demonstrate the activity.

The role of royal jelly in the development of queen bees has stimulated many investigations into its possible therapeutic role in many human diseases, including leukæmia[8]. In most instances, the reports have been incomplete and difficult to assess. The present report appears to be the first unequivocal demonstration of an anti-tumour activity in royal jelly. The results have been confirmed repeatedly on nearly 1,000 mice during a 2-year period, and show a striking effect: either all the mice die quickly or all survive. Two groups of mice which received tumour cells plus royal jelly remained alive and healthy more than 12 months after inoculation, while sister mice which received the same number of tumour cells without royal jelly died within 12 days.

The royal jelly ether-soluble fatty acid used in this study was isolated originally by Townsend and Lucas in 1940[2] and was later identified by Butenandt[9] as 10-hydroxydecenoic acid. The dependence of its biological activity on *p*H suggests that only the undissociated fatty acid is effective. Identification of the active constituent of royal jelly as a fatty acid is of interest in view of the recent demonstration[10] that ascitic tumour cells can metabolize such compounds readily.

Further studies are in progress to determine whether the active material causes death of the tumour cells before inoculation, as reported previously by Burchenal *et al.*[11] with certain chemotherapeutic compounds. The study has been extended to an investigation of structural derivatives of 10-hydroxydecenoic acid and closely related compounds.

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Serotonin and Change of Colour in Frogs

IT is well known that intermedin, a secretion of the pituitary, is responsible for the dispersion of the pigment in the melanocytes of frogs. The identity of the secretion has remained a mystery; indeed, there are few compounds capable of causing the darkening of hypophysectomized frogs.

Recent experiments in this laboratory have revealed that the indolamines tryptamine and 5-hydroxytryptamine (serotonin) disperse the pigment in the melanocytes of hypophysectomized specimens of *Rana pipiens* when injected into the dorsal lymph space. The effect, recorded by photographing an area of the web of the foot at intervals after the injection, is short-lived; dispersion of the pigment is apparent within 15 min. after injection and lasts an additional 15–30 min. At the end of this time, the pigment returns to its normal concentrated condition, but some reinforcement of the effect can be obtained by a second injection while the pigment is dispersed. The degree of dispersal achieved during these experiments does not approach that encountered in a fully darkened frog in Nature, but the effect is definite and striking. The chemicals were administered as solutions in Ringer's solution of tryptamine hydrochloride and 5-hydroxytryptamine creatinine sulphate in doses ranging from 10 to 1,000 μgm.

Other compounds with pharmacological properties similar to those of serotonin have been tested and found to exert no melanophorotropic effect. Thus, in the present study, histamine acid phosphate and acetylcholine bromide failed to disperse the pigment, and Hogben and Winton[1] found that tyramine was without effect.

Extracts of frog pituitary gland in Ringer's solution produce total dispersion of the pigment lasting

several hours when injected into hypophysectomized frogs. Injection of 100 μgm. of lysergic acid diethylamide, considered to be an inhibitor of serotonin, with the pituitary extract results in a return of the pigment to the contracted condition much more quickly. This experiment can be regarded as providing indirect evidence that serotonin is involved in the darkening process. A similar antagonism between serotonin and lysergic acid has already been reported for the chromatophores of fish[2].

Using an extraction technique based on that of Weissbach, Waalkes, and Udenfriend[3], extracts have been prepared from frog pituitary glands. When such extracts are evaporated to dryness to eliminate the toxic organic solvents involved in the extraction process, and the residue is dissolved in Ringer's solution, they exhibit melanophorotropic activity in the same way as the indolamines when injected into hypophysectomized frogs. On the other hand, an extract prepared from frog nerve cord has no effect.

However, ultra-violet absorption studies with these extracts have demonstrated that the material is not serotonin. The hypothesis that it may be a derivative or precursor of 5-hydroxytryptamine is under examination in this laboratory.

I am indebted to Dr. W. E. Beckel, in whose laboratory this work is being done, for his interest and encouragement, and to the National Research Council for financial support.

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Lack of Effect of Histidine on Rabbit Atheromatosis

Chimakadze[1,2] has published an interesting report on the treatment with histidine of rabbits fed with cholesterol. He claimed that daily administration of 80 mgm. of histidine for 20 days lowered the serum cholesterol-levels by 1,000–1,300 mgm. per cent and markedly diminished the deposition of aortic lipids. In view of the potential importance of these claims we decided to repeat and extend the experiment.

Twenty-one white New Zealand rabbits from four litters (litters I, II, III contained 5 animals, litter IV, 6 animals) were divided into five groups. Each group was composed of one member from each litter; the fifth group had 2 litter mates. Groups 1 and 2 were given 100 gm. 'Purina' rabbit chow containing 0·375 gm. cholesterol a day. Groups 3 and 4 received the same amount of chow containing 0·750 gm. cholesterol a day. Group 5 served as a control to check possible hereditary hypercholesterolæmia or the presence of spontaneous aortic lesions. The animals received the diets for 92 days, and food consumption records were obtained for each animal. After the first 50 days the rabbits of groups 1 and 3 were given by stomach tube 80 mgm. of histidine in 4 ml. water a day. (DL-Histidine hydrochloride was chosen since Chimakadze did not specify the type of histidine used, and since experiments in rats[4] and mice[5] have shown that D-histidine is converted to L-histidine.) The animals of groups 2 and 4 were given by stomach tube 4 ml. of water only. Serum cholesterol was determined by the method of Pearson *et al.*[3] before starting the cholesterol diet, every 10 days during the first 50 days, and once each week during the remainder of the period. The evaluation of the degree of the aortic lipid deposition was made by gross observations of the excised aortas according to a standard scale employed in our laboratory.

Animals fed with the lower cholesterol diet showed the same degree of slight atheromatosis, those fed with the higher cholesterol diet the same degree of more severe lesions into the aortic wall. Thus our results have shown no difference in the extent of lipid deposition in the aortic wall of the histidine-treated group when compared with the animals receiving water. The serum cholesterol-levels showed a gradual increase from the initial levels of 117 ± 9 mgm. per cent to final levels of 363 ± 171 mgm. per cent on the 0·375 gm. cholesterol intake and 1,073 ± 115 mgm. per cent on the 0·75 gm. cholesterol intake on the fiftieth day.

During the 22 days of histidine administration, when Chimakadze claimed a decrease of serum cholesterol by 50 per cent, 5 out of 7 of our water-treated group and 5 out of 6 of our histidine-treated group showed further and similar increases in their serum cholesterol-levels. We did not note any differences in cholesterol-levels in the different groups up to 37 days of histidine treatment, which was nearly twice as long a time as that employed by Chimakadze. At that time some of the histidine-supplemented animals developed some anorexia and the experiment was terminated. The animals in the control group were free from an elevation of the blood cholesterol-level or aortic fat deposits.

On the basis of our results we cannot explain the pronounced effect of histidine claimed by Chimakadze. The administration of 80 mgm. of histidine does not increase the total histidine intake significantly, since the animals already received 430 mgm. of histidine daily ('Purina' rabbit chow contains 0·43 per cent L-histidine; personal communication from P. E. Kifer, Ralston Purina Company.) Perhaps the Russian diets, which are not specified by the author, were marginal in histidine content. It is also possible that in the Russian experiment the administration of histidine altered the food intake, a factor which was controlled in our experiment but not mentioned by Chimakadze. A third possible difference may, of course, be in the strain of the animals.

In conclusion, it is apparent that the alleged lowering of cholesterol and anti-atherogenic activity of histidine could not be demonstrated under the conditions of our experiment.

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Reserpine Derivatives with Specific Hypotensive or Sedative Activity

RECENTLY it has been reported, by Ciba Laboratories[1,2], that two reserpine analogues show more specific effects than reserpine. Methyl-18-O(3-NN-dimethylaminobenzoyl)reserpate (or *SU* 5171) exhibits sedative activity, while carbethoxysyringoylmethylreserpate (syrosingopine or *SU* 3118) is effective in decreasing blood tension (see formulæ).

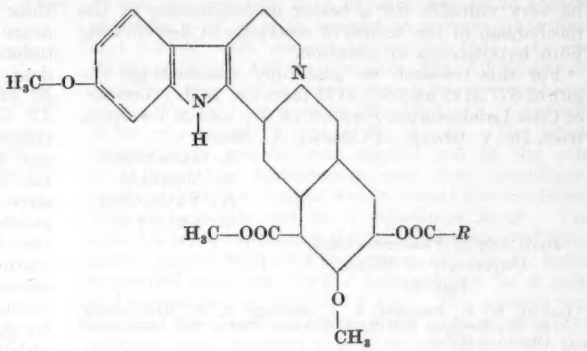
These results prompted us to investigate, on a quantitative basis, the difference between the two new compounds and reserpine during several tests.

Our experiments were carried out on Sprague–Dawley rats of both sexes, weighing about 200 gm. The compounds were injected intraperitoneally 4 hr. before the determinations reported here were made. Brain serotonin was assayed according to Bogdanski *et al.*[3] by the spectrofluorimetrical method. Blood pressure was recorded kymographically, by a Sanborn electro-manometer, following cannulation of the carotid artery, the animal being narcotized with ethyl urethane (100 mgm./100 gm. intraperitoneally). Body temperature was measured with an electrical thermometer introduced in the rectal cavity. Sleeping time after barbiturates was evaluated by injecting intraperitoneally 20 mgm./kgm. nembutal. Sedation was judged by observation of behaviour, responsiveness to commands and reduced interest in surroundings.

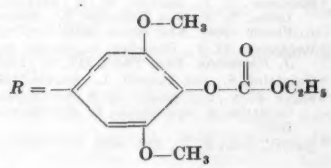
The results obtained are summarized in Table 1.

From these results it appears quite evident that *SU* 3118 and *SU* 5171 have, at least in rats, a specific effect. In fact, while for reserpine the minimal hypotensive dose and the minimal sedative dose are very close, for *SU* 3118 and *SU* 5171 they are clearly differentiated. In particular, for *SU* 3118 the onset of sedation occurs at 30 mgm./kgm., while the fall of blood pressure begins at 0·95 mgm./kgm.; for *SU* 5171 the two activities are present respectively at 5 mgm./kgm. and more than 30 mgm./kgm., the highest dose tested. Further experiments indicate that the sedative activity of *SU* 5171 (7·5 mgm./kgm.) is less persistent than the respective activity of reserpine (2·5 mgm./kgm.), since it disappeared after 36 hr.

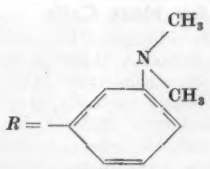
In agreement with a previous paper of ours on reserpine[4], for these new compounds also good correlation is shown between sedation, depletion of brain serotonin, fall in rectal temperature and increase in nembutal sleeping time. In particular the



Reserpine



SU 3118



SU 5171

Table 1

Compound	Mgm./kgm. (i.p.)	Blood pressure (mm. mercury) max.	Blood pressure (mm. mercury) min.	Brain serotonin (gamma/gm.)	Rectal temperature (° C.)	Duration of narcosis after nembutal (min.)	Sedation
Solvent	–	146 ± 7 (40)	83 ± 4 (40)	0·47 ± 0·008 (50)	37·5 ± 0·08 (30)	28 ± 3 (50)	–
Reserpine	0·31	131 ± 7 (10)	51 ± 7 (10)				–
	0·62	125 ± 11 (10)	43 ± 5 (10)	0·42 ± 0·04 (10)			–
	0·95	122 ± 5 (10)	44 ± 7 (10)	0·33 ± 0·02 (10)			±
	1·25	97 ± 4 (10)	55 ± 5 (10)	0·27 ± 0·01 (10)	35·3 ± 0·3 (10)	39 ± 5 (10)	+
	2·50			0·17 ± 0·005 (10)	34·0 ± 0·25 (10)	58 ± 7 (10)	+
	5·00			0·12 ± 0·018 (10)	32·3 ± 0·19 (10)	81 ± 4 (10)	+
SU 3118	0·62	136 ± 3 (10)	64 ± 4 (10)				–
	0·95	119 ± 5 (10)	41 ± 5 (10)				–
	1·25	105 ± 2 (10)	46 ± 2 (10)				–
	2·50	106 ± 3 (10)	50 ± 3 (10)	0·48 ± 0·06 (8)	37·0 ± 0·11 (10)	24 ± 8 (10)	–
	20			0·46 ± 0·005 (8)	36·7 ± 0·17 (10)	35 ± 4 (10)	–
	40			0·20 ± 0·009 (8)	33·2 ± 0·40 (10)	125 ± 7 (10)	±
	50			0·13 ± 0·012 (8)	33·0 ± 0·19 (10)	150 ± 2 (10)	+
SU 5171	2·5			0·48 ± 0·023 (8)	35·2 ± 0·21 (10)	52 ± 2 (10)	
	5			0·25 ± 0·009 (8)	34·7 ± 0·05 (10)	60 ± 1 (10)	±
	7·5			0·12 ± 0·005 (8)	33·6 ± 0·45 (10)	92 ± 2 (10)	+
	10	139 ± 3 (10)	60 ± 10 (10)	0·14 ± 0·012 (8)	33·3 ± 0·18 (10)	119 ± 2 (10)	+
	20	138 ± 5 (10)	70 ± 7 (10)				+
	30	140 ± 6 (10)	55 ± 2 (10)				+

The number of animals used is given in brackets.

release of brain serotonin, induced only by the compound provided with sedative activity, supports Brodie's assumption[5] on the importance of depletion of brain amines in explaining reserpine sedation. On the contrary, the decrease in brain serotonin does not seem significant in explaining the hypotensive effect of reserpine. The possibility that *SU* 3118 is ineffective on brain serotonin for a poor penetration into the brain is questionable, since in some experiments we observed no changes in intestinal serotonin after 20 mgm./kgm., while reserpine (2·5 mgm./kgm.) or *SU* 5171 (7·5 mgm./kgm.) determined a depletion of about 40 per cent. The use of these new compounds, besides their clinical importance[6], seems to be very valuable for a better understanding of the mechanism of the action of reserpine in determining both hypotension or sedation.

For this research we gratefully acknowledge the gift of *SU* 3118 and *SU* 5171 from Dr. A. J. Plummer, of Ciba Laboratories, Summit (N.J.), and of reserpine from Dr. V. Ghetti, of Ciba s.p.A., Milan.

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Differences in Mechanism in Staining Reactions for Mast Cells

Mast cells are usually identified histochemically by the use of aldehyde fuchsin[1], Hale[2] or Rinehart[3] stain, or by the metachromasia they exhibit with certain basic dyes. All these methods demonstrate mucopolysaccharides, although differences in the degree of staining of various mucopolysaccharides with the several methods have been noted[4]. Peracetic acid oxidation (Greenspan's mixture 30 min., 25° C.)[5] of tissue sections has been found to induce staining of certain normally unreactive substances with aldehyde fuchsin[6–8], and to alter the susceptibility of oxytalan fibres to hyaluronidase, lysozyme and elastase[7]. During the course of investigations of mucopolysaccharide reactivity after peracetic acid oxidation, an interesting change was observed in mast-cell cytoplasms. Peracetic acid oxidation followed by digestion with enzymes which hydrolyse mucopolysaccharides resulted in diverse staining reactions with the above three methods for mucopolysaccharides.

The skin, tongue and other organs of adult *BALB/c* strain mice were used. Fresh 2-mm. thick specimens were taken and immediately placed in Lillie's[5] aqueous neutral calcium acetate formalin for 24 hr. at room temperature. The specimens were then washed, dehydrated, blocked in paraffin, and sectioned at 6μ.

Mast cells in control sections stained with either azure *A* (0·5 per cent in aqueous 0·2 *M* phosphate buffer *p*H 4, 30 min., 25° C.), aldehyde fuchsin or the Hale stain reacted brilliantly either with or without previous oxidation of tissue sections with peracetic acid. Peracetic acid generally enhanced the subsequent staining reactions. However, if sections were oxidized with peracetic acid and then digested with either β-glucuronidase (Nutritional Biochemicals Corp., 15 mgm.: 50 ml. 0·1 *M* acetate buffer *p*H 4·5, 24–48 hr., 37° C.) or lysozyme (Worthington, 5 mgm.: 30 ml. 0·2 *M* phosphate buffer *p*H 5·3 24–48 hr., 37° C.), no mast cells were affected by the Hale stain, and few with aldehyde fuchsin. The few that reacted with aldehyde fuchsin were only slightly stained. Nevertheless, all mast-cell granules and their cytoplasms remained strongly reactive with azure *A*; the staining reaction was only slightly reduced, if at all. Occasionally, testicular hyaluronidase (Nutritional Biochemicals Corp., 25 mgm.: 50 ml. 0·2 *M* phosphate buffer *p*H 6, 24–48 hr., 37° C.) would prevent the subsequent Hale staining reaction, but the results were erratic. No effect on any staining reaction was observed if sections were not oxidized with peracetic acid prior to the digestion step. Sections oxidized with peracetic acid and then incubated in the various buffer solutions for the same time-intervals stained with undiminished or nearly undiminished intensity. When peracetic acid-oxidized sections were incubated in either lysozyme or glucuronidase that had been boiled in its respective buffer for 5 min., the same results were achieved as with unboiled enzymes. This is consistent with a previous report that lysozyme retains full enzymatic activity after boiling in acid solution[9]. The effect of boiling on the enzymatic activity of glucuronidase has not been reported. Lysozyme was inactivated by boiling in alkaline buffer at *p*H 9 for 30 min. (confirming a previous report[9]), and mast cells reacted strongly with all stains after incubation in the usual manner with lysozyme treated in this fashion. Meyer *et al.* have reported the inhibition of lysozyme by iodine and hydrogen peroxide[9]. Lysozyme was almost completely inhibited by iodine (Lugol's 1 : 300 buffer), and moderately inhibited by hydrogen peroxide 30 per cent (1 : 15 buffer) as indicated by the nearly normal, and slightly diminished aldehyde fuchsin and Hale staining respectively of mast cells when incubated with lysozyme and inhibitor. Saccharic acid has been reported to inhibit glucuronidase[10]. Mast cells stained moderately with aldehyde fuchsin and the Hale method after incubation in glucuronidase with saccharic acid at 0·01 *M* concentration, but full staining was not achieved even after incubation with glucuronidase in saccharic acid at 0·1 *M* concentration, indicating moderate but not complete inhibition.

These results are compatible with the view that after peracetic acid oxidation, both glucuronidase and lysozyme enzymatically remove a component from mast cells that is stained with aldehyde fuchsin and the Hale stain, and that there remains a component inducing strong metachromasia with azure *A*. Since inhibitors which are not otherwise likely to alter the enzyme prevent the effect on the staining reactions, it is unlikely that the lack of staining with aldehyde fuchsin and the Hale stain in this case represents an uptake of basic protein by acid mucopolysaccharides rendering these groups unavailable to the stains. This type of blockage has been previously reported[11–13]. The reactions clearly demonstrate that although all the above three methods stain mucopolysaccharides, the granules and other cytoplasmic components of mast cells, the staining reactions are

not equivalent and probably are not staining the same substance.

I wish to acknowledge especially the technical assistance of Mr. Clifton Link, jun.

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PATHOLOGY

Purification of the Mouse Mammary Carcinoma Agent by means of a Fluorocarbon

THE use of fluorocarbons for removing host cell components from aqueous suspensions leaving viral particles in relatively pure form in the aqueous phase was suggested by Gessler, Bender and Parkinson[1]. Epstein[2] has demonstrated the utility of this technique in the purification of vaccinia and the Rous sarcoma viruses.

Recently we have reported the identification of the mouse mammary carcinoma agent by correlation of its physical and biological properties making use of filtration through 'Gradacol' membranes, ionizing irradiation and free diffusion[3]. In addition, the structural development of the agent *in vitro* in tumour explants has been traced[4]. Since the fine structure of the agent is now believed to be established, it has become feasible to follow purification procedures by electron microscopic examination of thin sections of ultracentrifugalized pellets.

In a typical example, a spontaneous mammary carcinoma weighing 5·5 gm. from a mouse of the *R*III strain was minced and then homogenized in 40 ml. of a solution 0·15 *M* with respect to sodium chloride, 0·02 *M* with respect to sodium phosphate and 0·2 *M* with respect to sucrose (*p*H 7·4) and 20 ml. of 'Freon 113' or 'Genetron 226' ($CF_2Cl\text{-}CCl_2F$) (density 1·6). The homogenization was accomplished with a 'VirTis' homogenizer (The VirTis Co., Gardiner, N.Y.) run at 45,000 r.p.m. for 2 min. The whole fractionation process was carried out in the cold (0–5° C.). The homogenate was then centrifuged at about 300*g* for 1 min., which caused the emulsified 'Freon' to settle out as a gelatinous layer. The aqueous layer containing the virus was removed from above, mixed with half its volume of 'Freon', again emulsified with the 'VirTis' homogenizer for 2 min. and centrifuged at 300*g* for 1 min. The process was repeated five or six times until the supernatant aqueous layer became almost water-clear. As the soluble proteins and lipids are removed by the 'Freon', the amount of 'Freon' which may be emulsified becomes reduced and the excess will remain as clear liquid underneath.

After the last low-speed centrifugation, the supernatant fluid was spun at 3,000*g* for 20 min., and relatively large gelatinous pellets, presumed to be made up of 'Freon' micelles, were formed. The supernatant was then water-clear and contained the

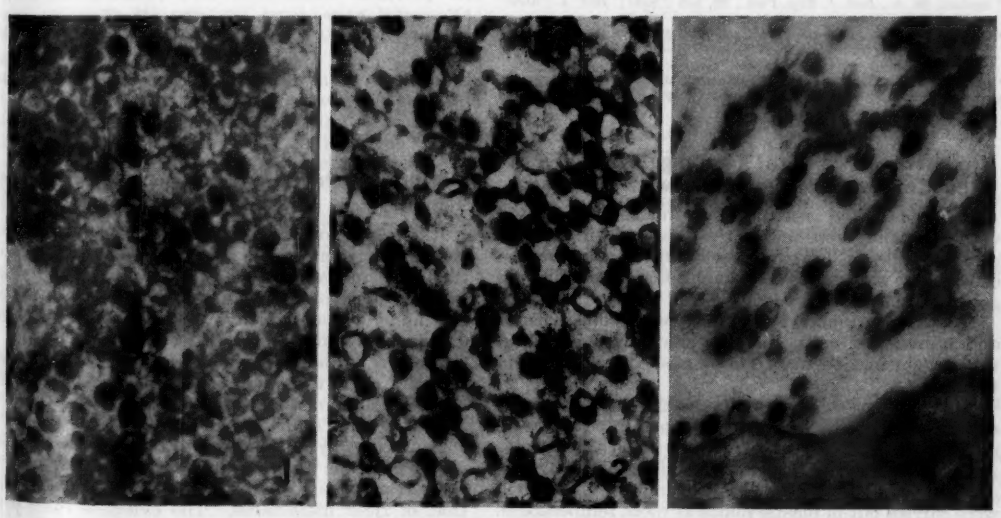

Fig. 1. Electron micrograph of sectioned pellet showing profiles of the milk agent. Since the thickness of the section is less than a third of the diameter of the particles, only segments of many spheres are caught in the section. (× 40,000)

Fig. 2. Electron micrograph of a section from another preparation where the bodies are not so closely packed and the contrast is better. (× 48,000)

Fig. 3. Electron micrograph of mammary carcinoma tissue showing the milk agent particles along the cellular membranes and lying free in the intercellular space. (× 35,000)

desired bodies, which were pelleted out at 100,000*g* in 1 hr. This small pellet was very white, but turned brown when fixed with 1 per cent buffered osmium tetroxide solution. The pellets obtained after centrifuging at 3,000*g* did not, on the other hand, turn brown in osmium tetroxide. The fixed pellets were prepared for electron microscopy in the usual manner employed for tissue. Electron micrographs of thin sections of final pellets are illustrated in Figs. 1 and 2. For comparison, Fig. 3 shows the appearance of particles in tumour cells recently identified as the milk agent[3,4].

We have used the same process for purifying the agent from the culture medium of explants of tumour fragments from the *R*III mice, as well as from the milk of these mice. The preparation from the milk was not so pure as those from either the tumours or the culture mediums. Milk is rich in non-viral particles, which are not easily separated by the procedure described here.

Profiles of the milk agent are easily recognizable in the electron micrographs. The characteristic structure of these particles consists of a dense nucleoid about 25 mμ in diameter contained within a membraneous sac about 100 mμ in diameter. The nucleoid occasionally appears centred, but more often it is eccentric, appearing near or in contact with the surrounding membrane. The membrane is 8–10 mμ thick and appears to be of the same structure and density as the membrane of the cells which liberate the bodies[3,4].

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Impairment of Viral Hæmagglutination of Red Cells after Treatment with Formalin

It was reported recently[1] that mouse cells treated with formalin were more readily agglutinated by some strains of myxoviruses than were untreated cells, and it was suggested that this finding might have general application.

We wish to report briefly that with some viruses and human red cells, the opposite holds good, and that agglutination may be abolished by formalin treatment.

Group O red cells were treated with formalin as described by Gold, Lockyer and Tovey[2]. They were incubated at 37° overnight, then washed three times in saline. Phosphate-buffered saline, *p*H 7·4, was used as a diluent in the hæmagglutination tests which were carried out in plastic plates at room temperature.

This experiment has now been repeated using the 6-hr. formalin treatment described by Fauconnier and Barua[1], but with phosphate-buffered saline instead of isotonic saline for suspending the cells and for the dilutions. The results were similar to the previous experiment and are given in Table 1.

Table 1. Effect of Treatment with Formalin on Agglutinability of Red Cells

Virus strains	Reciprocal hæmagglutination titre		Ratio *A*/*B*
	Fresh cells (*A*)	Treated with formalin for 6 hr. (*B*)	
Myxoviruses			
Influenza A (Mel)	80	80	1
Influenza *B* (Lee)	40	30	1·3
Sendai	8	32	0·25
Columbia *SK**	20	20	1
Adenovirus type 9	6,400	300	21
ECHO viruses			
Type 10	96	<1	>96
Type 11 (*U* virus*)	512	<1	>512

* Sheep cells in veronal buffered saline used (ref. 4)

It will be seen that, with the myxoviruses and *Col SK* virus, the titres are either unchanged or enhanced, but that agglutination has been greatly reduced or abolished in the case of the adenovirus 9 and the two *ECHO* viruses tested. Other experiments showed that red cells treated with formalin failed to absorb *ECHO* 10 and 11 viruses, and absorbed adenovirus type 9 less well than untreated cells. Myxoviruses were absorbed equally well by treated and untreated cells. These findings support the view that myxoviruses and *Col SK* virus[4] react with similar red-cell receptors, and that these are distinct from those with which *ECHO* viruses[5] and adenoviruses react.

These results were obtained in the course of an investigation comparing the hæmagglutination reaction found in viruses of various groups and will be published in full later.

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Ploidy of Primary and Metastatic Human Tumours

Repeated observations conducted over many transplant generations on animal tumours have shown that the modal chromosome ploidy may change during the passages. This change is always toward the higher value of ploidy; changes in the opposite direction have never been observed[1].

Nothing is known about these events in the human tumours since transplantation of tumours from one human being to another is, of course, not feasible. Metastasis in human tumours, however, may be considered a type of self-autotransplantation. The objective of the present study was to compare the cell population ploidy of human primary tumours with that of their metastases. The evidence to be presented was collected from human tumours obtained at surgery (4 breast adenocarcinoma with axillary lymph node metastasis) and at necropsy (1 breast adenocarcinoma with liver and bone metastasis; 1 nasopharyngeal carcinoma with liver and adrenal metastasis).

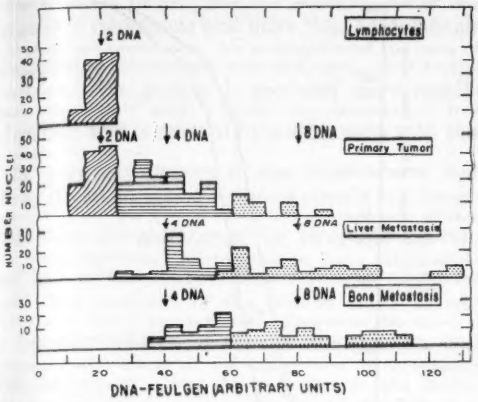

Fig. 1. Distribution in the single nuclei of the deoxyribonucleic acid-Feulgen material in one case of adenocarcinoma of the breast. The arrows correspond to the average value of the single modal class—2 DNA, 4 DNA, 8 DNA are the di-tetra-octoploid classes

With the microspectrophotometric technique, repeated absorption measurements of the deoxyribonucleic acid of single interphase nuclei were made at 546 mμ on Feulgen-stained sections. The product of extinction and volume was taken to be proportional to the amount of deoxyribonucleic acid per nucleus. The total number of nuclei measured for each primary tumour and its metastasis was approximately 500. The primary tumour, its metastasis, and the control lymph node were fixed together, embedded in the same paraffin block and prepared on the same slide. The positive correlation of the quantitative measurement of the deoxyribonucleic acid–Feulgen by microspectrophotometry with deoxyribonucleic acid measurement by ultra-violet microspectrophotometry, with biochemical analysis, and with chromosome counts have established the technique as a suitable method for the evaluation of the nuclear chromosomic set[2,3].

The distribution of deoxyribonucleic acid in the population of cell nuclei of a breast adenocarcinoma is shown in Fig. 1. The histogram shows a first modal class at the same position (2 DNA) for the control lymphocytes and primary tumour cell nuclei. This group of elements corresponds to the diploid class. The 4 DNA and 8 DNA class in the primary tumour nuclei population is an expression of the well-known hetero-polyploid chromosomic condition. The metastatic lesions, localized in the liver and bone (skull) are deficient in the diploid class in comparison with the primary tumour of origin.

The same behaviour was observed in four other cases when the metastatic growth in the lymph node was compared with the primary mammary adenocarcinoma. A similar lack of the diploid class was evident in the liver and adrenal metastasis of a nasopharyngeal carcinoma in contrast to the primary tumour where the diploid class is present. No significant differences were seen between the ploidy of the metastatic lesions in different organs of the same subject. The nuclear volumes of tumour cells were significantly greater in the metastatic lesions and the distribution of the volume estimations had a wider spread than the values found in the primary tumour.

It has been reported that nearly all tumour cell emboli are arrested in the vascular network of the first organ encountered, and that there the earliest and most numerous metastases develop. The concept that these arrested cells always lead to metastatic growth is not in accord with some experimental data from mouse and rat[4–7], with observations obtained from studies in human beings of cancer cells in the blood stream without recognizable metastases (Potter, J. F., and Malmgren, R. A., personal communication) and with the fact that the majority of the arrested emboli apparently fail to produce metastatic foci by extension and growth within the tissues[8–10]. This means that the number of fully established metastatic foci is much less than the number of tumour cells which enters the blood stream and has the opportunity of implantation in a given organ of a subject carrying a malignant tumour.

In the present study the infrequency of diploid cells in the metastasis, in comparison with the primary tumour, suggests the possibility of a cytogenetic basis for the phenomenon of metastasis. It is possible that all types of cells may be released from the tumour and circulate in the vascular or lymphatic stream, but when they become lodged only a few (the heteroaneuploid) can develop and become established as metastatic loci. Another possible interpretation of the results is that only the heteroploid cells leave the tumour, embolize in the blood stream and establish secondary growths. Whatever the cause, the end-result is a cell population, in the metastasis, differing from the population in the primary tumour. This difference suggests that cells with a heteroploid chromosomic number have a greater capacity for survival and the establishment of metastatic foci when they are transferred to a new site and a new environment.

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BIOLOGY

Infectious Ribonucleic Acid as Precursor of Tobacco Mosaic Virus

In an earlier communication[1], it was reported that the latent period after infection with virus ribonucleic acid is about 10 hr. shorter than after infection with complete tobacco mosaic virus. The simplest explanation for this effect is that the release of ribonucleic acid from the virus takes some time. But even after infection with pure ribonucleic acid, there is a latent period of about 10–20 hr. We have now studied the events during this remaining period in some detail. It seems possible that the first event

after infection is a multiplication of the released ribonucleic acid and that a certain amount of it has to be formed before the synthesis of the virus protein can be initiated; this protein will later combine with the ribonucleic acid to form the complete virus.

Infectious ribonucleic acid cannot be detected when the extraction is carried out with aqueous solutions because it is destroyed by the ribonuclease present in the tobacco leaves. To determine the free ribonucleic acid in the presence of virus nucleoprotein we used the following technique. Leaves of infected *Nicotiana tabacum* (Samsun) were homogenized in the presence of phenol and phosphate buffer. Thus the enzymes of the leaves are destroyed immediately after disruption of the cells and the infectivity of the ribonucleic acid is preserved and can be determined after removal of the phenol phase. By this extraction we obtain the total ribonucleic acid (that is, free ribonucleic acid plus virus-ribonucleic acid). In parallel experiments the amount of virus or virus-ribonucleic acid was determined by two different methods. Part of the same tissue was extracted by buffer without phenol, and the amount of complete virus was bioassayed on *N. glutinosa* as already described[1]. Since tobacco mosaic virus produces many more local lesions than virus-ribonucleic acid, the ratio of free ribonucleic acid to virus-ribonucleic acid can be calculated only indirectly by this method. To determine directly the ribonucleic acid bound in the virus the infected leaves were homogenized with buffer as before and the solution was incubated for 1 hr. at 37° C. to inactivate the free infectious ribonucleic acid. Ribonucleic acid which is within the virus remains intact after this treatment. The protein was then extracted with phenol and the activity of the liberated virus-ribonucleic acid was measured.

Several series of experiments were carried out in the following way. Young plants of *N. tabacum* (Samsun) were infected with a solution of 10^{-6} gm. tobacco mosaic virus per ml. as previously described[1]. The plants were kept under constant illumination at 23° C. After certain intervals the primarily inoculated leaves were harvested. For each determination eight plants were used. Part of these leaves was homogenized with 0·01 *M* phosphate buffer at *p*H 7·2 and phenol. The phenol was removed with ether and the aqueous ribonucleic acid solution was used for the local-lesion test. The remaining leaves were homogenized with buffer alone. An aliquot of this latter extract was used for the determination of the complete virus. The main portion was incubated at 37° and treated with phenol afterwards for the determination of the virus-ribonucleic acid.

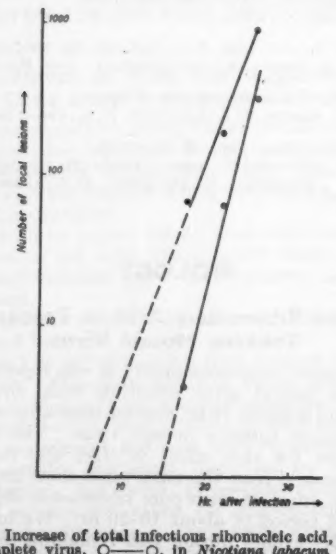

Fig. 1. Increase of total infectious ribonucleic acid, ●——●, and complete virus, ○——○, in *Nicotiana tabacum* measured by the local-lesion test on *Nicotiana glutinosa*

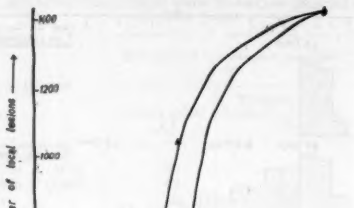

Fig. 2. Increase of total infectious ribonucleic acid, ▲——▲, virus-ribonucleic acid, ●——●, and free ribonucleic acid, ○- - -○, in *Nicotiana tabacum* after infection with tobacco mosaic virus measured by local-lesion test in *Nicotiana glutinosa*

Results of two typical experiments are illustrated in Figs. 1 and 2. In Fig. 1 the increase of total infectious ribonucleic acid and of complete virus measured by the number of local lesions is plotted on a logarithmic scale. At first the activity of the total infectious ribonucleic acid was much greater than the activity of the complete virus. 18 hr. after infection, the total ribonucleic acid produced 68 lesions and the virus only 4. As tobacco mosaic virus produces per mole about 1,000 times as many local lesions as ribonucleic acid, the amount of free ribonucleic acid is about 17,000 times that of the tobacco mosaic virus; 22 hr. after infection the ratio was about 4,000. In Fig. 2 the numbers of local lesions produced by the total ribonucleic acid and by the virus-ribonucleic acid obtained after incubation and phenol treatment are compared. The difference between the two curves (representing the free ribonucleic acid) is also plotted. It is interesting that the amount of free ribonucleic acid reached a maximum after about 45 hr. and decreased to a small value after 100 hr.

The experiments show that, after infection, a considerable amount of infectious ribonucleic acid is produced before the synthesis of the virus protein starts. This infectious ribonucleic acid, which is not incorporated in the virus, is called free ribonucleic acid. Of course, it is not certain whether it is really free or bound to some other unknown material. From Fig. 2 it can be seen that the difference of time between the rise in free ribonucleic acid and the incorporation of ribonucleic acid in the

virus is about 10 hr. For the envelopment of one molecule of ribonucleic acid more than 2,000 peptide sub-units are necessary. An estimation of the rate of production of ribonucleic acid and virus leads to the conclusion that protein is produced more rapidly than ribonucleic acid. Thus, the amount of free ribonucleic acid is reduced by combination with this protein.

In earlier experiments it was demonstrated that during the latent period complete virus is not detectable. Our results give a plausible explanation of this fact. After the entrance of the virus into the cell, the virus particles disintegrate to form ribonucleic acid and protein. The ribonucleic acid multiplies first. The synthesis of the protein starts several hours later, but is much faster. Therefore the amount of free ribonucleic acid reaches a maximum, and decreases afterwards as a consequence of combining with the protein. The latent period in the multiplication of the virus is mainly due to the fact that the release of the ribonucleic acid and its multiplication take some time before the formation of the protein and of the complete virus starts.

Further evidence of free ribonucleic acid as a precursor of tobacco mosaic virus is the inhibition of virus multiplication when ribonuclease is introduced before, or shortly after, the virus[2,3]. The presence of infectious ribonucleic acid in tobacco plants infected with tobacco mosaic virus was also deduced by Cochran[4] from chromatographical experiments.

We are grateful to the Deutsche Forschungsgemeinschaft for financial support.

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A New Method for the Microbiological Oxidation of Steroids

THE microbiological steroid transformations in the preparation of sex- and adrenocortical hormones opened a new field for the use of micro-organisms in organic synthesis. An interesting feature of these reactions is the ability to transform substances which are practically insoluble in water in an aqueous medium. It seems obvious that this transformation does not take place in the aqueous phase itself but on the lipoid surface of the micro-organisms. When the fermentation broth and the mycelial mass are treated separately after such transformations, the fermentation broth contains relatively more polar transformation product and less starting material, whereas considerable quantities of the initial steroids could be recovered from the mycelial mass.

Peterson and Murray[1] reported an 80–90 per cent yield of 11α-oxyprogesterone, prepared with *Rhizopus nigricans* from progesterone, and they also found 6β-11α-dioxyprogesterone and 11α-oxyallopregnanedione in the broth. Our strain of *Rhizopus nigricans* gave a 60–70 per cent yield with the dioxy-compound as a by-product. In a fermentor, using glucose, corn-steep liquor, and sodium chloride for the culture medium, and about 10^8 spores per litre for the inoculation, *R. nigricans* grows as a voluminous

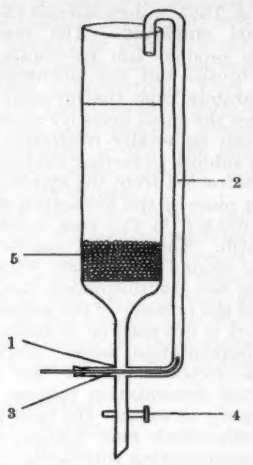

Fig. 1

mucous mass. If the inoculum consists of 10^5 spores per litre it grows in pellets, that is, globules 3–4 mm. in diameter. In our experiments, 400 ml. from a culture of this type were placed in a chromatographic column of 4 cm. diameter fitted with a sintered glass plate, No. *G*–1. The apparatus is shown in Fig. 1. The fluid rises through the lower four-way joint (1) into the glass tube (2), placed alongside the column, the bent part of which reaches into the column. Air is blown through a capillary (3) and thus the broth is continuously forced from the tube into the column and saturated with air at the same time. To the fluid thus kept in constant circulation 160 mgm. of progesterone dissolved in 4 ml. of acetone were added. The speed of circulation of the broth was 250 ml./min. At 6, 8, 10, 12, 14, 16 and 18 hr. after the addition of progesterone, 250-ml. portions of the fermentation broth were drained off through the lower stopcock (4) and the same quantities of fresh broth added. The 6, 8 and 10 hr. portions contained 40 mgm. progesterone each, consequently a total of 280 mgm. of progesterone was added. The experiment was stopped after 20 hr. The broth samples were shaken with twice their volume of dichloroethane, the mycelium globules (5) retained in the column were extracted twice with 10 ml. of acetone and three times with dichloroethane, using 100 ml. of this solvent altogether. The extracts were washed with a 2 per cent solution of sodium bicarbonate, then with water, dried with sodium sulphate and, finally, investigated quantitatively by paper chromatography[2].

Table 1

Sample taken at (hr.)	Contents of 11α-oxyprogesterone (mgm.)	Progesterone (mgm.)
6	58·8	—
8	51	—
10	35·6	—
12	33·8	—
14	30	—
16	21·8	—
18	9·7	—
20	3·7	—
From mycelium	0	38
Total	244·4	

Total recovery of steroids, 282·4 mgm.; conversion yield, 86 per cent

The results in Table 1 demonstrate the advantages of the method employed. The uncontaminated transformation product can be obtained from the fermentation broth, and the unchanged substrate recovered separately from the mycelial tissues. No loss occurs since the small quantity of untransformed progesterone can be totally recovered. The useful product is not subject to further oxidation since it is continuously extracted from the system. Tap-water can be used in place of the fermentation broth when changing the fluids; in this case recovery becomes more simple still. The method can be used for all microbiological steroid conversions where the organism performing the transformation can be grown in pellet form and the polarity of the substrate molecule to be converted is not such as to make it soluble in the aqueous fermentation broth. Further, by this microbiological method, one of the great inconveniences of the fermentation process is obviated: it is not necessary to extract the final product from the whole broth, which may contain a number of undesirable contaminating substances.

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A Rare Sperm Abnormality: 'Corkscrew-sperms' associated with Sterility in Bulls

Williams and Savage[1] introduced a semen examination method for the evaluation of the seminal micropathology in bulls, the results of which in the hands of the experienced examiner are of definite value in sterility work, especially in classifying the severity of testis degeneration and testis hypoplasia. Later investigators have used slightly different systems for classifying abnormal sperm forms, but most workers have included abnormalities of the middle piece of the sperm in their counting as rather rare forms[2–4].

In 100 normal fertile bulls which I examined in 1950, by counting 500 sperms from each case, middle piece defects were only demonstrated in 0·27 per cent of the primary sperm abnormalities. Furthermore, in a long series of semen slides from cases of sterility in bulls examined by me during the past 15 years, middle piece abnormalities were never found as the main defect.

It was therefore of great interest to receive, within a period of a few months, from different parts of the country, abnormally thin semen samples from two sterile bulls showing almost the same morphological picture: most of the sperm heads were normal, but a high percentage of the sperms had middle pieces shaped like a corkscrew (Fig. 1), an abnormality which I had previously regarded as a curiosity.

By ordinary microscopy (× 1,000) the corkscrew sperms were easily seen and counted in slides stained with eosin–nigrosin[5] (Fig. 1*c*). In simple wet preparations also the abnormality was clearly distinguishable, especially by phase-contrast (Figs. 1*a* and *b*). None of the abnormal sperms was motile and none of them remained unstained (alive-reaction) with eosin–nigrosin.

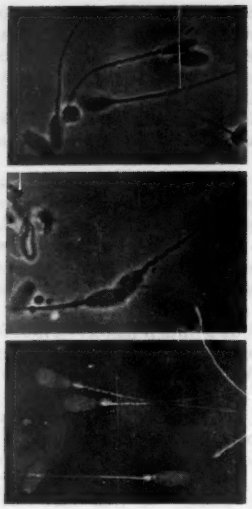

Fig. 1. Photographs showing typical corkscrew-sperms together with apparently normal sperms (×600). (*a* and *b*) Phase-contrast exposures from wet preparations; (*c*) a slide stained with eosin–nigrosin

Case 1. RDM bull, 5 years old. Until December 1957 the bull was used regularly at an artificial insemination centre. Semen quality and fertility: fair. Dilution rate: generally 1 + 2 only. From January 1958 semen quality was going down, motility almost nil and concentration decreasing rapidly, so the bull was taken out of use. Clinical examination, July 1958: testis normal sized, probably with some fibrous induration.

Table 1

Date of semen examination	Motility (per cent)	Sperms/mm.³	Corkscrew sp. (per cent)
Aug. 27, 1958	< 1	40,000	24
Sept. 2, 1958 (I)	< 1	100,000	15
Sept. 2, 1958 (II)	< 1	50,000	16

Diagnosis: Testis degeneration, cause unknown.

Unfortunately this bull was sent for slaughter without further examination being made.

Case 2. RDM bull, 12 years old. Has belonged to the same artificial insemination centre for about 11 years. During the first 9 years the bull was used regularly three times weekly and always had semen of top quality and high fertility. When the bull was about 10 years old sperm concentration decreased somewhat and fertility dropped to fair. From April 1958 the semen was practically dead and of low concentration (last successful insemination March 1958). This bull is still alive.

Table 2

Date of semen examination	Motility (per cent)	Sperms/mm.³	Corkscrew sp. (per cent)
Oct. 22, 1958 (I)	< 1	200,000	23
Oct. 22, 1958 (II)	< 1	100,000	27
Nov. 5, 1958	< 1	200,000	31
Nov. 19, 1958	< 1	75,000	45
Dec. 1, 1958	< 1	75,000	49

Diagnosis: Testis degeneration, cause unknown.

The occurrence of characteristic corkscrew sperms with twisted middle pieces in 15–49 per cent by the differential sperm count in two sterile bulls (primarily fertile) seems to indicate the existence of a hitherto rare form of testis degeneration, where the specific blastema for the middle piece, including the so-called mitochondrial sheet, is affected.

Of these two sterile bulls it was only possible to follow one during a short period before slaughter, while semen samples from the other were examined during some months, showing that the occurrence of corkscrew-sperms increased regularly, from 23 to 49 per cent, while, as a decrease in sperm concentration indicated, degeneration of the testis tissue was in progress.

Only Bretschneider[4] (drawing 114) seems to have encountered a similar phenomenon, with a sort of macrohelix-structure in the middle pieces in 20 per cent of the sperms, but unfortunately no photographs and no information about the fertility of the bull in question are given. These results seem to indicate that investigators who are doing morphological sperm examinations for fertility in bulls should pay full attention to the condition of the middle pieces, and in future work also include corkscrew-sperms in the group of primary sperm abnormalities.

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Hair as a Substrate for Non-Keratinolytic Fungi

DURING a study of the fungal succession occurring on hair decomposing in contact with soil, it has become apparent that hair, either autoclaved or sterilized with propylene oxide, can support the limited growth of many fungi which are not keratinolytic. Thus species of *Mortierella*, *Cunninghamella* and *Chaetomium*, as well as of many genera of the Fungi Imperfecti, for example, *Aspergillus*, *Gliocladium*, *Penicillium*, *Alternaria*, *Curvularia*, *Epicoccum*, *Helminthosporium*, *Phoma*, *Pyrenochaeta*, grow sparsely on the hair surface and produce spores there.

The ease with which such fructifications can be examined has led to the use of hair as a fungal substrate for class purposes while teaching mycology. Fine human hair, sterilized either by autoclaving at 15 lb. pressure for 15 min. or with propylene oxide[1], is placed on the surface of a thin layer of agar of low nutrient status contained in a Petri dish, and the agar is inoculated with the fungus to be studied. Within a few days, the mycelium has spread from the agar to colonize sparsely the hair surface, and scattered conidiophores are produced. A hair is then carefully removed with forceps and mounted on a slide in any suitable mounting fluid. The preparation, under a cover-slip, can then be readily examined under a microscope. The great advantage of the method lies in the ease with which an inexperienced worker can obtain an undisturbed preparation of conidiophores and conidia, clearly revealing the exact method of production of the latter, a detail which is assuming an increasing importance in taxonomy[2]. Although the mode of production of conidia remains typical, the poverty of hair as a substrate for the majority of fungi occasionally leads to a simplification in conidiophore morphology. Thus in the genus *Penicillium*, the penicillus is frequently of a simpler nature than the corresponding structure produced on an agar medium, so that the hair technique is not satisfactory when specific identification is attempted in such genera.

The method has also proved advantageous in promoting either the asexual reproduction of apparently sterile cultures or the production of more easily characterized structures in those cultures which produce nothing but an ill-defined mass of simple slime spores on the normal agar media. In many cases cultures of either of these types have readily produced pycnidia on the hair surface.

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Discoloration of Wool Fibres by a Fungus

A COMPLAINT by a wool processer in Japan that part of a consignment of New Zealand raw fleece wool in the coarse-quality range was affected by a black discoloration which could not be removed in the ordinary wool scouring process, or by any common solvent, has been investigated and the cause of the discoloration established as being due to a fungus growing in the fibres.

In outward appearance the distal part of the staple was dark coloured and similar in appearance to wool contaminated by dust and dirt. All parts of the fleece appeared to be equally affected. On scouring or after solvent-treatment the affected staple tip remained dark. In the region of discoloration, fibres had a very low tensile strength characteristic of extreme weathering.

Microscopic examination showed the fibre to be outwardly intact. Large fungal hyphæ were obvious within the fibre and cross-sections showed a severe mechanical disruption of cortical cells within the fibre, this no doubt contributing to the loss of tensile strength. Within the fibre the hyphæ are moniliform in shape and dark in colour. At irregular intervals the hyphæ anastomose and fruiting structures are formed which finally reached the surface by breaking through overlying cortical and cuticular cells of the fibres. Minute hyaline ellipsoidal unicellular or two-celled spores are produced in these structures.

The fungus was isolated from affected wool by placing short lengths of the infected fibres on tryptone glucose extract agar ('Difco') to which 0·01 gm./ml. of 'Terramycin hydrochloride' had been added aseptically just prior to pouring the plates. The fungus, which grew out readily, was transferred to slants of the same medium, where it formed fruiting bodies profusely. The fungus is reported by the Commonwealth Mycological Institute to be a species of *Peyronellaea*, not recorded from wool but close to *Peyronellaea glomerata* (Corda) Goidanich, and has been disposed in the Commonwealth Mycological Institute herbarium as *I.M.I.* 74752.

No reports of fungus damage to unprocessed wool have been found in the literature, although several unidentified actinomycetes have been shown to be capable of bringing about a rapid disintegration of wool fibres while still on the sheep[1], and this present report indicates a further source of damage by a group of organisms that has been little studied in relation to the fleece.

Further investigations into the methods of spread of the fungus and its infection of wool are in progress and a full account will be published elsewhere.

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Abnormal Development of the Basis in *Balanus amphitrite* var. *stutsburi* Darwin

The deformation of barnacle shells by growth on unfavourable substrates is now well known[1,2]. The distinctive scalloped form of basis produced on toxic anti-fouling paints has been illustrated by these and other authors. The same deformity occurs when settlement takes place on a toxic metal surface, for example, the copper sheathing of a wooden hull.

Recent examination of some specimens of *Balanus amphitrite* var. *stutsburi* Darwin from "West Africa" in the City Museum, Bristol, dating from the mid-nineteenth century and conceivably belonging originally to Samuel Stutchbury, showed that four of the five specimens handled have this deformed basis (Fig. 1). The fifth is regular in outline except where distorted by two small encrusting oyster shells. Spectrographic examination of green material in the crevices of the contorted bases indicated a high percentage of copper. No copper was associated with the other smooth-shelled specimen. Nor was any found in the glue used to secure the specimens to the display 'tablet'. It is practically certain therefore that the deformed specimens are derived from the bottom of a copper-sheathed ship on which they arrived in Great Britain, presumably from West Africa, the home of this variety.

In the Darwin cirripede material in the British Museum (Natural History) there are mounted on a tablet, among other named varieties, eight numbered specimens assigned to *B. a. stutsburi* in a manuscript list in Darwin's hand. Of these, five are distorted specimens, one (No. 18 on the tablet) possibly the original of Darwin's illustration of the variety (Pl. V, Fig. 2*d*)[3]. Thus Darwin illustrated a deformed specimen only while also having normal material before him. This is still the only illustration of the complete shell of *B. a. stutsburi*.

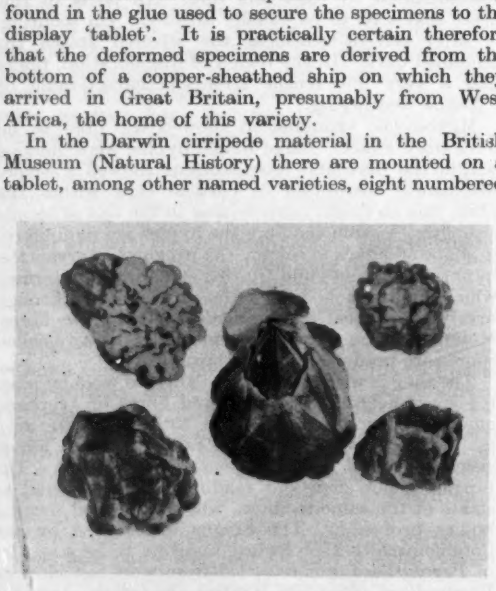

Fig. 1. *B. amphitrite stutsburi* Darwin. Four deformed specimens from a copper substrate and one normal smooth-walled specimen. (Bristol City Museum Collection)

Current examination of a large collection of new material of the variety from West Africa has shown that the rugged or deformed type figured by Darwin does not occur on natural and non-toxic substrates, for example, shells, stones, wood, concrete and iron, and that *stutsburi* is normally a smooth variety of *B. amphitrite* in its natural habitat.

The form and variability of this and some other varieties of *B. amphitrite* will be discussed at greater length in subsequent papers to be published, in collaboration, elsewhere.

I am indebted to the Director, City Museum, Bristol, for the loan of the specimens figured here, to my colleague, Mr. L. G. Young, for the spectrographic examinations of the copper-containing inclusions from the bases, and to the Director, British Museum (Natural History), for permission to examine the Darwin and other material in that Museum.

H. G. Stubbings

Admiralty Materials Laboratory,
Holton Heath,
Poole, Dorset.
Feb. 24.

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A Quantitative Serum–Agar Technique

While investigating the changes which occur in plant cytoplasmic proteins during growth and differentiation, using the Ouchterlony serum – agar plate technique[1], the need arose for a quantitative method of estimating the protein constituents. Although there are several methods available[2–7], none of them is easily applicable to a multi-antigenic system, and in addition the concentrations of the proteins can only be estimated separately, even under favourable conditions, at ±10 per cent and more usually ±50 per cent.

With the method described here it has been possible, with the system studied, to estimate the relative protein concentration within ±4 per cent, and it is probable that the technique could be developed to limits of ±2 per cent. The sensitivity of the technique is dependent on at least three factors: standardization of procedure; the titre of the individual protein or proteins; and the accuracy with which one can pipette the small volumes of liquid which have to be used when the antiserum, and sometimes the antigen solution, is in short supply.

The method consists of titrating antigen on to antibody and following the titration on a modified Ouchterlony plate. Two end-points are obtained (Fig. 1): (*a*) where free antibody is just detectable; (*b*) where free antigen is just detectable.

The technique is as follows: into a series of small tubes is pipetted a standard volume of antiserum (0·1 ml. of monospecific siderophilin antiserum was used in these experiments). To each of these is added the same volume of antigen in a series of different concentrations (normal human serum diluted

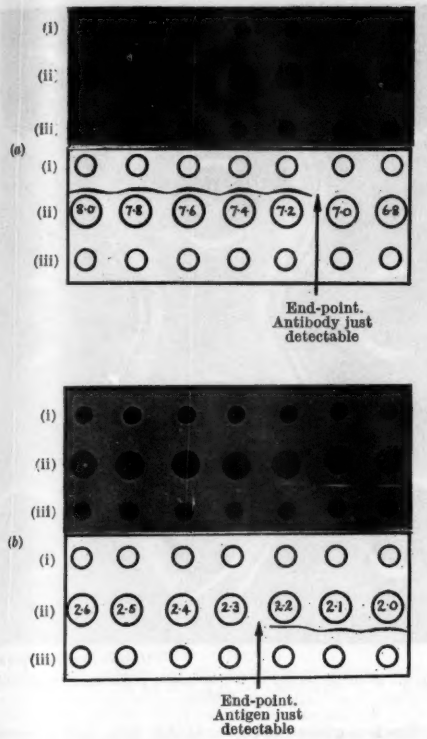

Fig. 1. The determination of the two end- or extinction-points for siderophilin : *a*, where free antibody is just detectable ; *b*, where free antigen is detectable. (i) Total human serum diluted × 8 ; (ii) monospecific siderophilin antiserum absorbed with a range of concentrations of total serum ; the figures indicate the dilution of the antigen ; (iii) the above antiserum diluted × 4

with physiological saline). The antibody and antigen are allowed to react for 2 hr. at 37° C. and then agar plates are set up as shown in Fig. 1 (0·6 per cent w/v New Zealand agar in veronal buffer, *p*H 8·6 (sodium diethylbarbiturate 0·1 *M* ; diethylbarbituric acid 0·02 *M*)) using equal volumes of absorbed antiserum in each well and similarly for unabsorbed antiserum and antigen. The plate is incubated at 37° C. for 20 hr. and the end-point determined visually. (37° C. was used for both the initial reactions and for the end-point detection test ; in certain circumstances, especially with weak antiserum, periods at 0° C. might be preferable.)

This experiment describes the determination of the two end-points for a standard antigen solution when

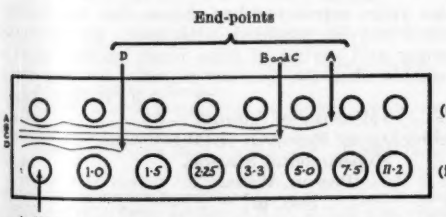

Fig. 2. Hypothetical example of the determination of the end-points (that is, where free antigen is just detectable) of a multiple protein system : (i) antiserum ; (ii) antiserum absorbed with a range of concentrations of antigen. The figures indicate the dilution of the antigen

used in conjunction with a particular antiserum. To estimate the concentration of the antigen in an unknown solution it would be necessary to determine only one of the two end-points (preferably the sharper, usually, as in this instance, the one where antigen is just detectable) and to express it in arbitrary units based on the standard. In the rare event of a pure antigen being available the end-point could be expressed as mgm. protein.

On theoretical grounds the end-point where antigen is just detectable is likely to be the more sensitive, because it is favoured by the shape of the precipitation curve, which is usually not symmetrical about the equivalence point, and because a small amount of antigen is more easily detectable than a small amount of antibody. Using this end-point for a multiple protein system several lines can be identified by setting up a plate as shown in Fig. 2, which shows a hypothetical example of the simultaneous estimation of all four antigens.

I wish to thank Prof. J. R. Squire for his encouragement and advice and Dr. P. G. H. Gell for his constructive criticisms.

The work was carried out under a grant from the Nuffield Foundation.

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Photographic Recording of Agar Diffusion Plates

A NUMBER of requests have been received at this Establishment asking for details of the method and materials used for the photographic recording of agar diffusion plates[1–4]. It may be of help to those using the Ouchterlony[5] and Mansi[6] techniques if the successful system devised and regularly in use here is made more widely known.

It was found that the greatest contrast, both visual and photographic, between the lines of precipitation and the background, is obtained when the beam of transmitted light is as nearly as possible normal to the agar surface, without the source itself being visible to the eye or the lens. The apparatus shown in Fig. 1 is one of the most compact and stable arrangements which will fulfil this condition. The bright aluminium sheet serves to reflect excess light and heat from the 500-watt spotlights, and has a circular aperture a little larger than that of the blackened dish support, which is separated from it by washers as spacers to prevent heat transfer. Standard 9-cm. Petri dishes are generally used, but a series of metal annuli, blackened on top and bright underneath, having 9-cm. outside diameters and three registering pegs set equilaterally around the inside diameters, support smaller dishes centrally over the aperture, and at the same time exclude excess light. Using a 13·5-cm. Tessar lens, 9-cm. dishes are photographed at a small degree of direct enlargement (to

11 cm.) on quarter-plate cut film. A stop of *f*/8 gives sufficient depth of field to bring the whole thickness of agar into focus. With high-contrast film (Ilford 'Ortholine', *G*5.51) and an exposure time of 1/50 of a second, 5 min. development in a standard phenidone-quinone developer (Ilford *I.D.* 62) allows adequate contrast, without blocking up the finer and fainter lines.

As the plane of light falling on the Petri dish tends to be diametral, separation of a close-running 'family' of lines, particularly where strong and faint ones are adjacent, is greatest when their direction is set parallel to that plane, as otherwise the scatter of light from the heavy lines may overshadow the finer ones. Lines of a circular precipitation zone around a cup are well differentiated even when at right angles to the light plane; this is not always the case with fully annular lighting, such as that from a Quebec colony counter, in which the rays are much nearer parallel to the agar surface.

Since this method of lighting was designed to accentuate the faintest lines to the greatest possible degree against a dark background, it follows that dust and fibres on the agar, and scratches on the bottom of the Petri dish, are also brought into prominence. Debris on the surface can be kept to a minimum by care taken when the dish is opened for inspection of the lines. Scratches and irregularities on the bottom of the Petri dish can be removed effectively, for the purpose of photography, by temporarily 'cementing' the dish to a scratch-free and flawless glass disk of suitable size with glycerine, avoiding the inclusion of air-bubbles.

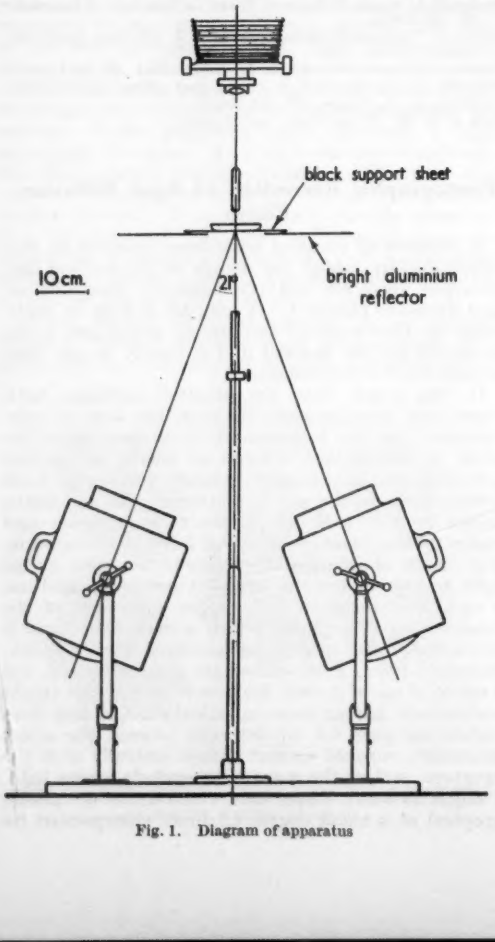
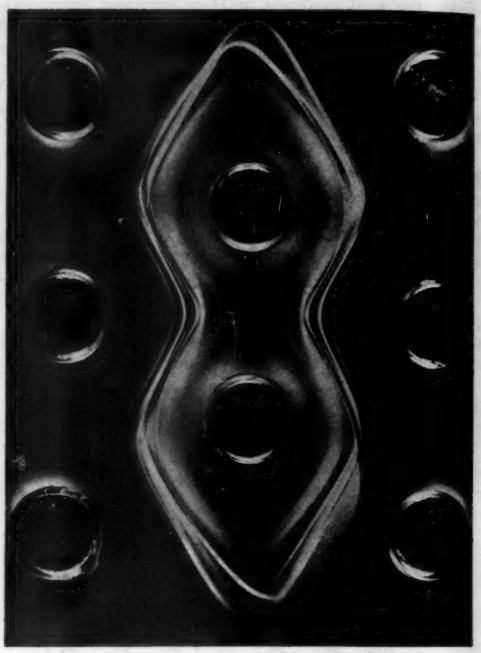


Fig. 1. Diagram of apparatus



[*Crown copyright reserved*

Fig. 2. Routine record of a *Pasteurella pestis* antigen–antibody system

In order that the equipment may be used for routine recording by staff who are not trained photographers, the number of variables has been kept to the absolute minimum. The camera, which is also used in conjunction with other equipment, is fixed to the wall, and has register marks on the adjustable stays. The spotlights and dish support, in one unit on a baseboard, are centred under the lens by means of spacing-rods to the wall. Negative processing is standardized by time and temperature. The greater degree of direct enlargement of smaller Petri dishes is compensated for in the normal way by an increase in exposure time, but is not often needed. There is sufficient latitude, even with the high-contrast emulsion used, normally to cover the amount of variability inherent in the diffusion plates themselves and good-quality negatives are obtained with the standard exposure time. Very little practice is needed to learn when slight adjustments will be required.

Two years experience has shown that the faintest of lines can be recorded with ease, and with an accuracy and saving of time much greater than is obtainable when the lines are recorded by drawing.

J. R. Hunter

Ministry of Supply,
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Feb. 6.

[1] Burrows, T. W., and Bacon, G. A., *Brit. J. Exp. Path.*, **37**, 490 (1956).
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[5] Ouchterlony, O., *Ark. Kemi, Min., Geol.*, **26**, B, 1 (1949).
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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 4

FARADAY SOCIETY (at the Imperial College of Science and Technology, South Kensington, London, S.W.7), at 4.30 p.m.—Dr. Robert Gomer (University of Chicago): "Surface Diffusion" (Bourke Lecture).*

LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE (at Houghton Street, Aldwych, London, W.C.2), at 5 p.m.—Prof. M. J. Wise: "Industrial Location—a Geographical Approach"* (Inaugural Lecture).

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Council Room of the Science Museum, Exhibition Road, South Kensington, London, S.W.7), at 5.30 p.m.—Dr. Churchill Eisenhart: "The Background and Evolution of the Methods of Least Squares".

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. D. J. Ayres: "Grouting and the Civil Engineer".

UNIVERSITY OF LONDON (in the Large Chemistry Theatre, Royal College of Science, London, S.W.7), at 5.30 p.m.—Prof. W. Lochte-Holtgreven: "Magnetic Fields in Rotating Plasma".* (Last of three Special University Lectures on "Spectroscopic and Magnetic Studies of Thermally Excited Plasmas".)

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. J. R. Whinfield: "Research in Man-made Fibres". (Last of three Cantor Lectures.)

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Annual General Meeting, followed by Mr. E. L. Streatfield: "The Conveyor Concept of Water in Industry".

Tuesday, May 5

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Prof. A. L. Hodgkin, F.R.S.: "Propagation of Electrical Signals along Nerve Fibres".

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. V. B. Mountcastle (Johns Hopkins University): "The Central Nervous Mechanisms in Somatic Sensation".* (First of two Special University Lectures in Human Anatomy and Morphology. Further lecture on May 7.)

UNIVERSITY OF LONDON (at the Institute of Education, Malet Street, London, W.C.1), at 5.30 p.m.—Academician I. A. Kairov: "Education of Students in the Spirit of Patriotism, Peace and Friendship amongst the Nations".* (Further lecture on May 8.)

BRITISH COUNCIL, and the JOINT COMMITTEE ON STRUCTURAL CONCRETE (at Friends' House, Euston Road, London, N.W.1), at 6 p.m.—Mr. Felix Candela: "Ten Years Building Thin Shell Structures".

UNIVERSITY OF LONDON (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 6 p.m.—Prof. F. E. Zeuner: "The Origins of Domestication—a Synthesis".* (First of six lectures on "Animals in Archæology". Further lectures on May 12, 19, 26, June 2 and 9.)

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. I. M. Ross, Mr. C. P. Lea-Wilson, Mr. A. J. Monk and Mr. A. F. H. Thomson: "An Experimental Diode Parametric Amplifier and Its Properties".

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Annual General Meeting. Mr. C. Shaw: "Precision Cast Moulds and Tools for the Plastics Industry".

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—27th Annual General Meeting, followed by Mr. C. E. Hollis: "The Pursuit of Polymers" (Chairman's Address).

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. R. H. Scott: "The Potential Use of Aircraft for Agricultural Purposes (with particular reference to New Zealand)".

Wednesday, May 6

SOCIETY OF DAIRY TECHNOLOGY (at the Federation of British Industries, 21 Tothill Street, London, S.W.1), at 10.30 a.m.—Meeting on "Some International Aspects of the Dairy Industry".

INSTITUTE OF PETROLEUM (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Symposium on "Submarine Exploration for Oil" presented by Members of B.P. Exploration Co., Ltd.

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, Portland Place, London, W.1), at 5.30 p.m.—Annual General Meeting. 6.30 p.m.—Presidential Address.

UNIVERSITY COLLEGE, DEPARTMENT OF HEBREW (in the Gustave Tuck Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Theodor H. Gaster (Dropsie College for Hebrew and Cognate Learning): "New Light on the Dead Sea Scrolls".* (Further lecture on May 7.)

UNIVERSITY OF LONDON (in the Small Physics Lecture Theatre, Royal College of Science, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Prof. M. Biernacki (Marie Curie-Sklodowska University, Lublin): "Sur les Extréma des Combinaisons des Fonctions, Sous-Harmoniques et de leur Généralisations".*

UNIVERSITY OF LONDON (at Bedford College, Regent's Park, London, N.W.1), at 6 p.m.—Prof. D. J. van Lennep (Utrecht): "Recent Studies on the Personality of the Proficient Research Worker". (Further lecture on May 7.)

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATE AND STUDENT SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Annual General Meeting, followed by Films.

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Annual General Meeting, followed by Dr. S. G. Clarke: "Corrosion as a Design Problem" (Chairman's Address).

SOCIETY FOR ANALYTICAL CHEMISTRY (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Meeting on "The Design of Experiments in Analytical Chemistry". Dr. E. C. Wood: "The Fundamental Principles of Modern Experiment Design"; Mr. W. C. Wake: "Statistics in Standardizing Chemical Methods".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting—"As Others See Us". Chairman: Prof. A. V. Hill, F.R.S. Speakers: Dr. C. Kemal Reheem: "Some Views from Pakistan on British Science"; Dr. Thomas H. Osgood: "The American View"; Mr. A. C. Copisarow: "Impressions from Some West European Countries".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. David R. Newith: "Black Axolotl, and White".

Wednesday, May 6—Thursday, May 7

IRON AND STEEL INSTITUTE (at Church House, Westminster, London, S.W.1), at 10 a.m. daily—Annual General Meeting.

Thursday, May 7

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. W. T. J. Morgan, F.R.S.: "A Contribution to Human Biochemical Genetics: The Chemical Basis of Blood Group Specificity" (Croonian Lecture).

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. K. Mather, F.R.S., and Dr. J. A. Roper: "Cytoplasmic Inheritance"; Mr. W. T. Stearn: "Baron von Humboldt (1769–1859)".

LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE (at Houghton Street, Aldwych, London, W.C.2), at 5 p.m.—Mr. T. H. Marshall: "International Comprehension in and through Social Science"* (Hobhouse Memorial Lecture).

INSTITUTE OF REFRIGERATION (joint meeting with the LOW TEMPERATURE GROUP of the PHYSICAL SOCIETY, at the Memorial Building, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Mr. D. Hurden: "Cryogenic Liquids for Rocket Engines".

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. M. Waldram: "Lighting and Architecture".

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. Phyllis Kaberry: "Nsaw Political Conceptions".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. François Jacob (Institut Pasteur, Paris): "Viruses in Relationships with some Genetic Elements of the Cell".*

POLAROGRAPHIC SOCIETY (at "The Duke of York", 8 Dering Street, London, W.1), at 7 p.m.—Informal Discussion Meeting on "Some Problems Encountered in Anodic Polarography".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

Friday, May 8

ASLIB (in consultation with the BRITISH ASSOCIATION OF INDUSTRIAL EDITORS, the NORTH-WESTERN POLYTECHNIC, and the PRESENTATION OF TECHNICAL INFORMATION GROUP (at the Connaught Rooms, Great Queen Street, Kingsway, London, W.C.2), from 10.30 a.m. to 5 p.m.—Conference on "The Presentation and Interpretation of Technical Information".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. H. H. Plaskett: "Solar Rotation and Photospheric Circulation"; Dr. M. J. Seaton: "The Calculation of Recombination Spectra".

INSTITUTION OF ELECTRICAL ENGINEERS, MEDICAL ELECTRONICS DISCUSSION GROUP (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Microwave Radiation Hazards", opened by Dr. D. H. Shinn and Dr. N. L. Lloyd.

UNIVERSITY OF LONDON (at the Royal Holloway College, Englefield Green, Surrey), at 8.15 p.m.—Sir Edward Salisbury: "The Royal Botanic Gardens, Kew, 1759–1959".

Friday, May 8—Saturday, May 9

BRITISH SOCIETY FOR IMMUNOLOGY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1)—Spring Meeting.

Friday, May 8, at 11 a.m.—Symposium on "Delayed Hypersensitivity". Chairman: Prof. G. Payling.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, The University, Edinburgh (May 9).

SENIOR LECTURER IN THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, The University, Edinburgh (May 9).

JUNIOR BIOCHEMIST (with an honours degree)—The Secretary, Institute of Animal Physiology, Agricultural Research Council, Babraham, Cambridge (May 15).

JUNIOR LECTURER/LECTURER IN PHYSIOLOGY—The Secretary, The London Hospital Medical College (University of London), Turner Street, London, E.1 (May 15).

RESEARCH ASSISTANT (PHYSICAL CHEMIST), for work with organo-metallic compounds—The Secretary, The University, Exeter (May 15).

FORESTERS (2) (with a Diploma or a Certificate of a recognized foresters' training school and preferably aged between 20 and 25) on the Staff of the Southern Rhodesia Forestry Commission—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (May 16).

LECTURER or ASSISTANT LECTURER (interested in the mechanisms of reactions) IN THE DEPARTMENT OF ORGANIC CHEMISTRY—The Registrar, The University, Liverpool (May 16).

MAP CURATOR (preferably geography graduate with an interest in maps and bibliographic work) IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, The University Leeds 2 (May 16).

LECTURER (with qualifications in physical science or mathematics) IN THE DEPARTMENT OF EDUCATION—The Registrar, University College of Wales, Aberystwyth (May 18).

ASSISTANT LECTURER IN METALLURGY—The Registrar, The University, Nottingham (May 23).

ASSISTANT LECTURER (with a good honours degree in chemistry or agricultural chemistry) IN AGRICULTURAL CHEMISTRY—The Registrar, The University, Leeds 2 (May 23).

RESEARCH ASSISTANT (with a good honours degree in botany or biochemistry or chemistry) IN THE DEPARTMENT OF BOTANY, to assist in research on the mechanism of photosynthesis—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (May 23).

ASSISTANT LECTURER (with an honours degree in agriculture, animal physiology or animal nutrition, or a pass degree in agriculture with a suitable postgraduate diploma, or equivalent qualifications) IN AGRICULTURE (ANIMAL HUSBANDRY)—The Registrar (Room 22, O.R.B.), The University, Reading (May 30).

ASSISTANT LECTURERS (honours graduates) IN PHYSICS AND ZOOLOGY—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (May 30).

ESSO RESEARCH STUDENT (with, or expecting to hold, a good university degree with chemistry as the principal subject) IN CHEMISTRY—The Professor of Chemistry, The University, Southampton (May 30).

LECTURERS and ASSISTANTS IN EXPERIMENTAL PHYSICS, THEORETICAL PHYSICS, and ELECTRONICS, in the Natural Philosophy Department—The Secretary, The University, Aberdeen (June 1).

READER IN PHARMACOLOGY at Middlesex Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 1).

CHAIR OF BIOLOGY as applied to Medicine tenable at the Middlesex Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 2).

LECTURER/SENIOR LECTURER (preferably interested and with research experience either in Western industrial societies or in Africa) IN ANTHROPOLOGY, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 6).

RESEARCH FELLOWS (2) IN THE DEPARTMENT OF ANTHROPOLOGY AND SOCIOLOGY, Research School of Pacific Studies, Australian National University, to carry out and assist in the supervision of research in social anthropology and sociology amongst primitive and advanced peoples in Australia and neighbouring parts of the world—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 15).

ASSISTANT LECTURERS (2) IN ZOOLOGY—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey.

BIOCHEMIST (with an honours degree in chemistry or biochemistry, and preferably research experience) IN THE CHEMISTRY DEPARTMENT, to carry out research on trace elements in relation to diseases of farm animals—The Secretary, Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh 9.

CHAIR OF APPLIED MATHEMATICS; ASSOCIATE PROFESSOR; and an ASSISTANT PROFESSOR IN THE DEPARTMENT OF MATHEMATICS—Prof. H. H. Ferns, Department of Mathematics, University of Saskatchewan, Saskatoon, Sask., Canada.

DEMONSTRATOR IN PHARMACEUTICS, and a DEMONSTRATOR IN PHARMACEUTICAL CHEMISTRY—The Registrar, The University, Nottingham.

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